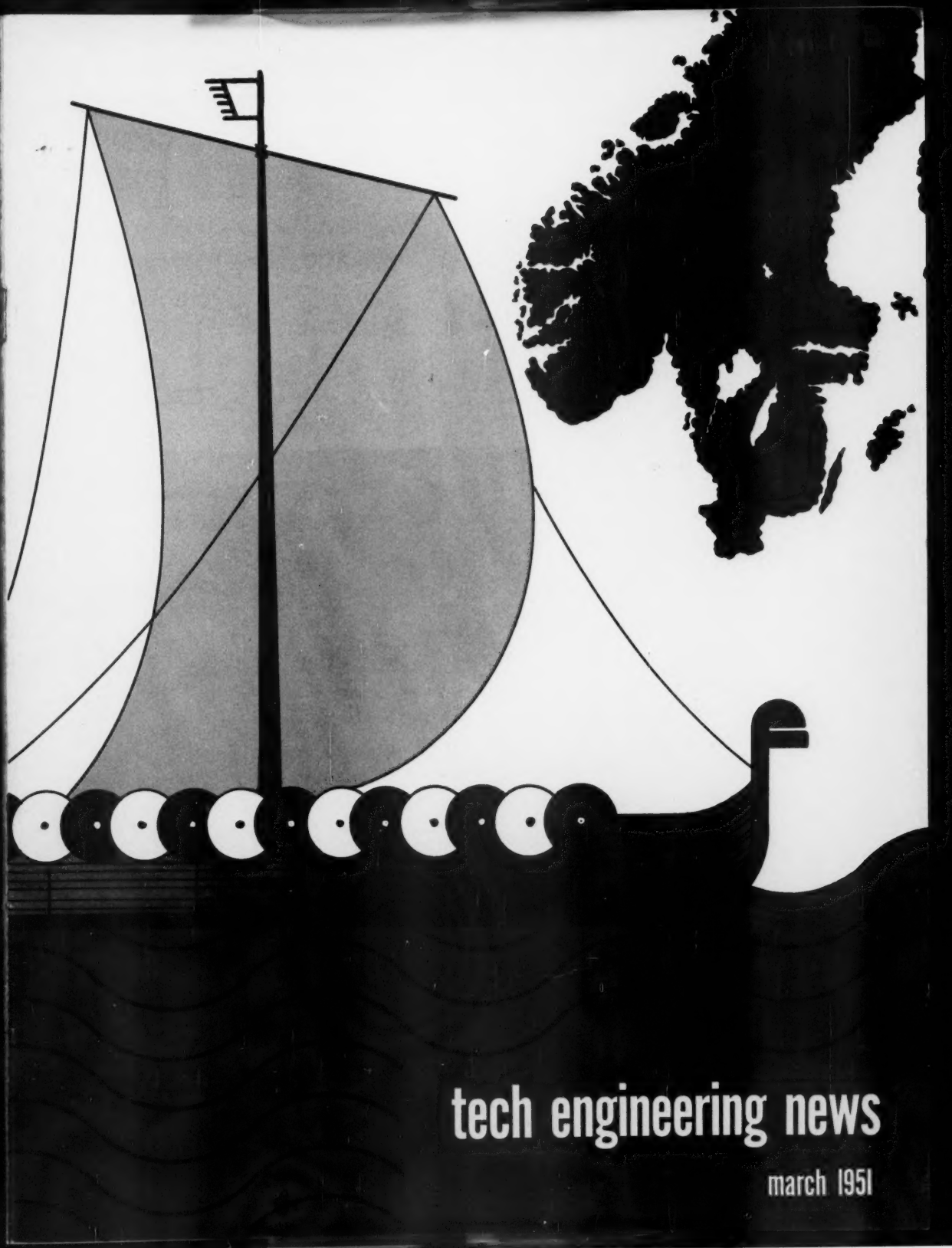
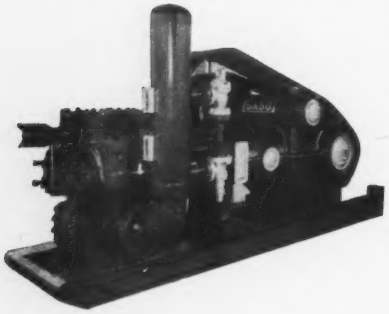


tech engineering news

march 1951

Another page for **YOUR BEARING NOTEBOOK**



How to keep a pump in its prime

Piston power pumps, used to pump oil through long pipelines, often have to operate 24 hours a day. To prevent breakdowns and minimize maintenance under this tough service, designers mount pump crankshafts on Timken® tapered roller bearings. Timken bearings take the heavy radial, thrust and combination loads. They prevent wear, insure trouble-free operation.

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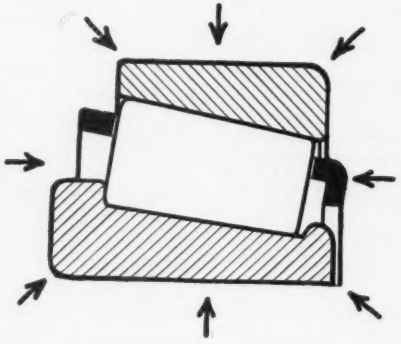
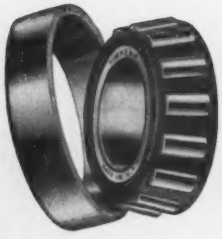
Due to their tapered design and line contact between rollers and races, Timken bearings carry the heaviest loads from any direction. They keep the crankshaft in proper alignment so that gears mesh more smoothly—last longer. And they eliminate crankshaft wear.





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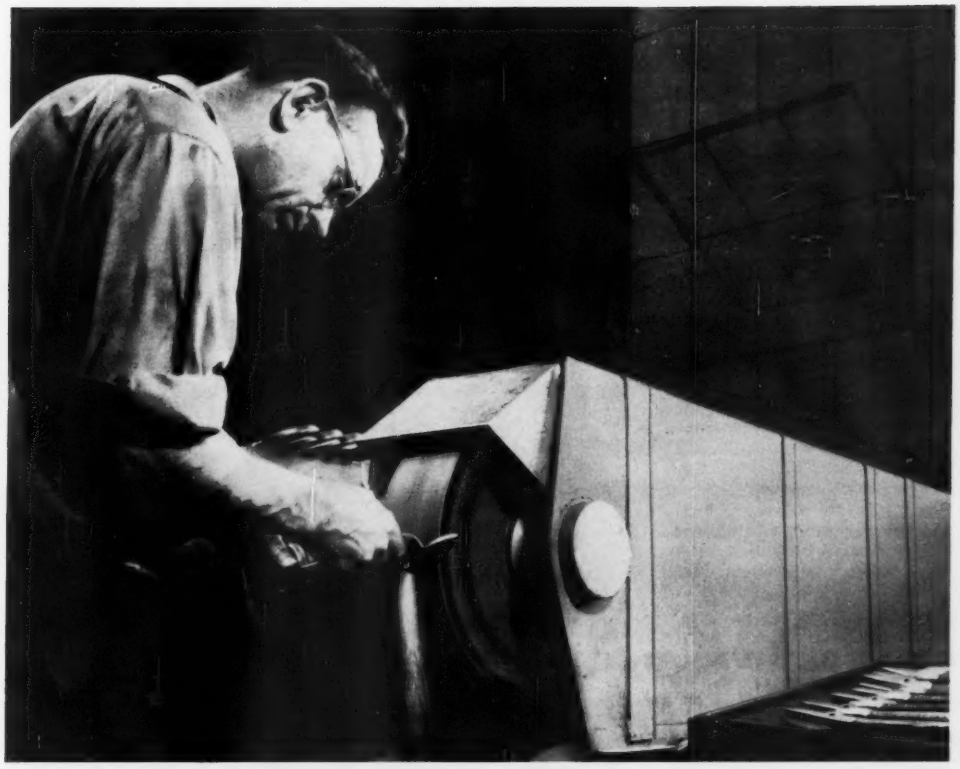
NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◐ AND THRUST —◐— LOADS OR ANY COMBINATION ✳



Could a wheel do it better?

A widely accepted method of finishing many parts and tools is by application of an abrasive belt of certain specifications. Yet, it is entirely possible that an improved method may some day be devised—the use of a special-type abrasive wheel, for instance…on a new type of polishing wheel.

Should this ever occur, CARBORUNDUM would undoubtedly be among the first to produce the right wheel. But, *even more important,* we would be fully prepared to explain the pros and cons of both methods. Because only CARBORUNDUM makes a *complete* line of abrasives…we can recommend *impartially* the right abrasive for every application based on our experience with all abrasive products.

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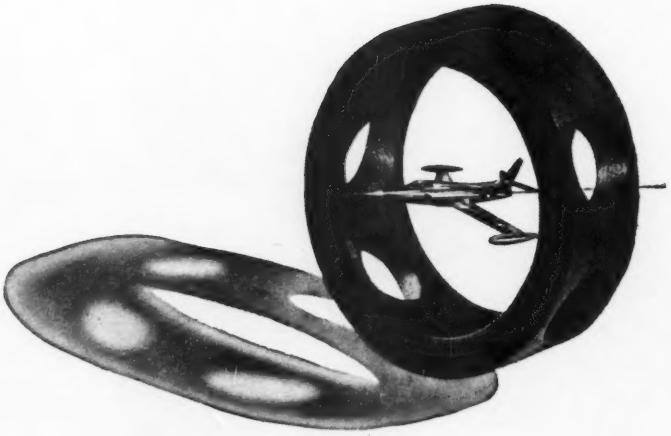

How to control a fast ball

When a jet airplane nears flying speed, its turbine rotor is spinning about 12,000 to 15,000 rpm. At that speed everything in the engine takes a beating.

Thrust and centrifugal forces are at work. Heat causes expansion stresses. Any imbalance sets up vibration. Then there is friction.

A jet engine is no spot for a part that can't take it.

One of the components that lead a hard life is the ball bearing for the main rotor shaft. It must be light in weight and compact. It must compensate quickly for distortion resulting from rapid and wide temperature changes. Shaft rigidity must be maintained and the bearing must overcome heavy gyroscopic forces and powerful thrust loads to do so. The shaft must be perfectly balanced to eliminate vibration at high rotary speeds.

An important part of the bearing is the ball retainer. A large bearing manufacturer selected Synthane laminated plastic for his retainer.

Synthane is tough and highly resistant to wear and abrasion. Synthane is light in weight. Synthane is dimensionally stable over the temperature ranges encountered. Oils or greases have little or no effect upon it.

These are a few Synthane characteristics. It has many others—physical, mechanical, chemical and electrical. This Synthane *combination* of properties and characteristics may be the answer to one of your problems. To find out, send for the latest Synthane folder.

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PLASTICS WHERE PLASTICS BELONG

SYNTHANE

THE DU PONT DIGEST

With silica, water and imagination
Du Pont scientists have found

How to Tame Slippery Floors

Teen-agers in high schools used to have great, if hazardous, fun running and sliding on newly waxed corridor floors. Of late many of them haven't been able to do that. For numerous schools, as well as office buildings and institutions, are now using waxes that have been made skid-resistant.

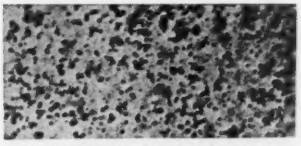
The product that is taming slippery floors is "Ludox" colloidal silica—adapted by Du Pont chemists to floor wax through cooperative research with the wax industry.

If you mix plain sand with floor wax, you'll have an anti-slip surface, but it would be unsightly and thoroughly impractical. With "Ludox," you are using a water suspension of invisible colloidal silica particles less than a millionth of an inch in diameter.

A problem child

"Ludox" was quite a problem child to scientists who developed it. For instance, research men had to know how silica would act in the presence of floor wax. So they turned to the electron microscope and learned that the little silica spheres attach themselves firmly to the surfaces of wax spheres five times their size.

But it was also necessary to find out how "Ludox" affects a waxy film after it is laid down on a floor. While a polished waxed floor looks smooth enough, it is actually a series of hills and valleys and these irregularities have an important bearing on the behavior of a surface.



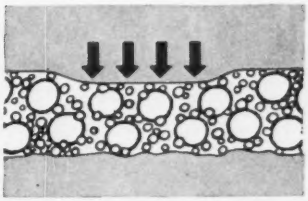
"Ludox" particles *(dark, in this electron photomicrograph) surround the larger wax particles throughout depth of film.* Magnified 25,000 x.

Du Pont "Ludox" *makes floor waxes harder as well as safer. Other wax qualities—gloss, freeze- and water-resistance, leveling—are unaffected. It is now used by many manufacturers.*

Working with a waxed surface presented difficulties. The electron microscope functions only if electron beams can pass through the membrane upon which the specimen is placed. And electrons can't "see through" a floor!

Study in duplication

Often, problems like this have been solved by preparing a thin replica or copy of the surface for examination in its stead. However, the conventional method for making a replica—the one frequently used in studying metals—requires solvents. These would dissolve and ruin a wax surface.



Cross-section *of wax film shows how pressure of foot pushes the hard "Ludox" particles into the wax, causing a snubbing action.*

So it became necessary for the chemists and electron microscopists to develop an entirely new way to make a replica of a surface. This they did, as part of a research program that lasted several years.

With it some remarkable pictures were made. They showed that many "Ludox" particles stay at the surface of a wax film, even though they are denser than wax. As you walk on a floor, your shoe presses the tiny silica particles down into the wax spheres that make up the film. This sets up a snubbing action which keeps you from slipping.

Much more could be told about Du Pont research on colloidal silica. For example, chemical and mechanical engineers had to develop manufacturing equipment, including a specially designed ion exchange column. Organic and physical chemists used research findings to formulate better waxes, as well as silica-containing adhesives and anti-slip treatments for rayon fabrics. Like practically all Du Pont achievements, "Ludox" is the result of close, continuous teamwork of men and women trained in many fields of science.

DID YOU KNOW . . .

it costs more than $10,000 on the average to provide the tools, machines, factory space and working capital for an American worker. Du Pont's average operating investment per employee is $17,800.

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tech engineering news

March 1951

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FRONTISPIECE

Rainmakers

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the gas turbine

By Ralph C. Johnston, G., and Jacob G. Bartas, G.

"The pin-up of the propulsion profession" is the way one writer described the present gas turbine engine. And he did so with good reason. Since the introduction of the aircraft jet engine in 1943 a steady development of the engine has resulted in an increase of output from the 1650-pound thrust rating of the first production model to the 7200-pound thrust rating of today's British Sapphire. These improvements have been widely hailed in the press with the result that the gas turbine is now considered the coming propulsion unit for just about everything that moves. Indeed, the Rover Company of England has produced a prototype gas turbine-powered automobile and the Boeing Airplane Company of this country has built and tested a 200-horsepower gas turbine truck engine. Several gas turbine locomotives are running experimentally on railroads here and in Europe.

While the aircraft and vehicular engines have been receiving the press agent treatment the techniques of using gas turbines in industrial processes and for the generation of electrical power have been developing in this country and to a greater extent in Europe with little public recognition. The stationary applications of turbines, of course, lack the glamour and dash of the aeronautical engines and thus have not received wide acclaim. But to gain a sounder understanding of the gas turbine one should consider the device's more mundane uses.

We would like here to review some of the achievements of gas turbines in the power field, but before so doing will briefly describe the gadget about which we are talking.

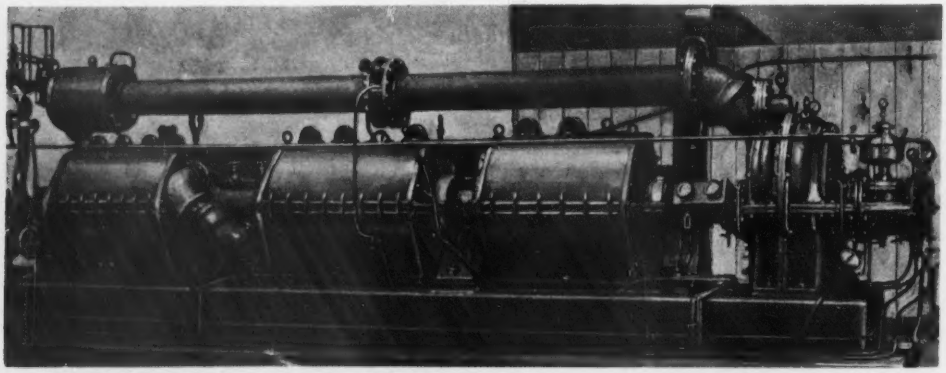
In its simplest form the gas turbine consists of three components. The first of the components is a compressor which raises the working gas, usually air, to a relatively high pressure. Almost any type of compressor could conceivably be used, but usually some type of rotary compressor such as axial or centrifugal is employed. From the compressor the gas goes to the second component, the burner, in which the gas is heated to a high temperature, generally between 1000 and 1500°F. The gas can be heated by either internal or external combustion — that is, by burning fuel in the gas itself or by heating the gas with a fire which does not contact the gas directly, similar to the way water is heated in a boiler. From the burner the heated and compressed gas passes to the turbine, the third component. In the turbine the gas expands to a lower pressure and in so doing imparts some of its energy to the turbine wheel. Part or all of the power developed by the turbine is used to drive the compressor.

The principal difference between aircraft and surface applications of gas turbines lies in the way the energy of the gas stream is utilized after it passes through the burner. In the common aircraft jet engine the turbine extracts from the gas only enough energy to drive the compressor; the remaining energy of the gas goes into producing a high velocity exhaust stream. It is the reaction force to that exhaust stream that produces the thrust needed to propel the aircraft.

For surface applications, however, a high energy exhaust stream is virtually useless. Thus in stationary installations (and in locomotives and ships) the turbine is designed to extract the maximum amount of energy possible from the gas. Part of that energy is used to drive the compressor and the rest is made available in the form of shaft power which may be employed any way desired.

Aircraft gas turbines which drive propellers (turboprops) produce both shaft power for the propeller and a jet for added thrust and therefore are a compromise between the two types described above.

As stated, the three-component gas turbine is the simplest form of the engine and is the form used in aircraft. The three components do not, however, exhaust the list of possible parts. Two more components commonly used in ground gas turbines must also be considered — the intercooler and the regenerator. Both the intercooler and the regenerator are essentially heat exchangers, devices in which two fluids at different

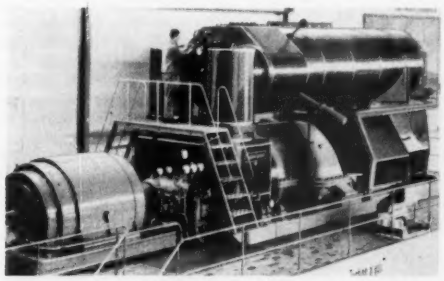


Gas turbine of the Societe des Turbo-moteurs, 1905. *Allis-Chalmers*

temperatures are brought into proximity, without mixing, so that heat may flow from one fluid to the other.

The intercooler is used to cool the working gas during the process of compression. When a gas is compressed its temperature increases and this temperature increase acts to impede further compression. It is therefore possible to accomplish a given amount of compression with reduced input of work by doing some compression, cooling the gas, and then continuing the compression. Incorporation of an intercooler in a compressor thus increases the efficiency of the operation.

A regenerator accomplishes the same purpose by the somewhat opposite action of adding heat to the working gas after compression. In gas turbines it is common practice to take the turbine exhaust gas, which is still at a relatively high temperature, and with it heat the air leaving the last stage of the compressor, thereby recovering some of the exhaust heat which would otherwise be lost.



Allis-Chalmers

Brown-Boveri turbine installed at Neichtal, Switzerland. This was the first commercial power-generating gas unit.

We have described five components for gas turbines. For efficiency in describing given installations it is customary to use a sort of shorthand of abbreviations to denote the arrangement of those components. We shall denote the units by C for compressor; I, intercooler; B, burner; T, turbine; X, regenerator. Therefore, the simple engine first described would be CBT. If a regenerator were used, the cycle would become CBTX and a two-part compressor with an intercooler would be CIC.

It can easily be seen that with five components to play with and any desired number of each, one can easily construct quite a variety of cycles. In general the efficiency of a gas turbine increases with increasing complexity. The principle of diminishing returns applies to the increase of efficiency and naturally the initial cost of the turbine increases with complexity, but large gas turbine installations are usually far removed from the CBT cycle. European designs are normally fairly complicated, a CICBTBTX being not uncommon. American units tend to somewhat simpler arrangements.

In addition to being affected by cycle complexity the efficiency of a cycle is a function of the temperature of the gas at the turbine inlet. The higher the temperature of the entering air the lower the density at compressor inlet and the less air the compressor can handle. As an illustration of the effect of atmospheric temperature the following figures for a Swiss turbine are presented:

Atmos. temp. °F.	0	40	80
Output, kw	13000	11000	9000
Efficiency, %	33.0	31.5	29.5

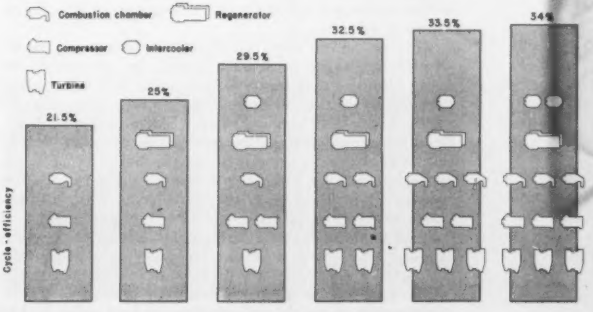
Having developed the originally simple turbine into what may at first appear to be a monstrosity, it is necessary to further complicate matters by remarking that the components may be run on a closed, open, or semi-closed cycle basis. In an open cycle fresh air is brought into the unit from the atmosphere, put through the cycle, and then exhausted to the atmosphere. In a closed cycle the working gas is constantly circulated through a closed circuit without contact with the atmosphere. Obviously, heating in a closed cycle must be done by some external means. Combinations of the two alternate extremes are denoted as semi-closed cycles. Closed cycles have the advantages of being free from turbine fouling caused by deposits of combustion products and of being capable of using any fuel available. The open cycle, because of its lack of a bulky heater, has the advantage of simplicity.

With the preliminaries out of the way it is now possible to discuss the actual turbines which have been installed. Although every technologically advanced nation is operating gas turbine power plants we will direct our attention mainly to Switzerland and the United States. The former is the leader in the field; the latter, of course, is of most immediate importance to us.

It should be remembered that the gas turbine is nothing new. The first practical turbines of the configuration used today were built in the early years of this century in Paris by the Societé des Turbo-moteurs. One of their units is shown in an accompanying illustration. The unit operated with an efficiency of slightly less than three per cent.

Work was carried on in later years in many quarters, the first principal use of gas turbines being made in 1932 with the introduction of the Velox steam boiler, a pressure combustion boiler in which an axial compressor furnishes air at about 30 psi gauge to the combustion chamber and the resulting combustion products actuate a gas turbine driving the compressor. Some eighty Velox units have since been built by the Swiss firm of Brown-Boveri.

PRACTICAL COMBINATIONS OF GAS-TURBINE ELEMENTS



The first United States application of gas turbines was made in 1936 when the Sun Oil Company incorpo-

(*Continued on page 20*)

a language for science

Some Possibilities for Better International Communication of Science

By James Stuart, '51

Have you ever opened a technical journal only to find that the first article was in English, the second in German, the third in French, and the fourth in Swedish? To some of you this may sound like a nightmare, but to the more initiated, it may sound like *Acta Chemica Scandinavica*, *Arkiv för Matematik*, or another of the dozens of journals of this type. They do exist.

It has been said, "Mathematics is the language of science," but the scientist, the engineer or even the mathematician who wishes to be informed on the latest discoveries in his field would add at least English, French, German, and Russian to the list and in some instances, Spanish and Portuguese. In another twenty years Kuo-Yu, the official dialect of Chinese, and Hindustani, the official language of India, which uses a Sanscrit alphabet, will have to be included, with Urdu, the language of Pakistan, as another possibility.

In the near future the situation will become much more serious. Industrialization and nationalism are coming to the "underdeveloped" lands of the world and are bringing with them national scientific and educational institutions which use native rather than foreign languages. Opening of greater educational opportunities to the lower economic classes and the concomitant rise to power of the socialistic and the Communist parties through the Eastern Hemisphere has brought an end to the governmental, cultural and scientific leadership by a well-traveled, cosmopolitan aristocracy. As a result, more and more in the future the discoveries of the scientists of India will be published in Hindustani rather than in English. The same will be true in China as scientists change from writing in English, French or German to writing in Chinese, much as has happened in Russia in the years since the Revolution in 1917.

The economic implications of this increasing diversity of languages of science should be of concern to every scientist and engineer, particularly in this period of rapid expansion of technology when solving almost every problem brings to mind a dozen new problems. No one, except perhaps the novelist or the poet, suffers economically or otherwise from the inability of those not literate in his language to read his works. In the case of science and engineering this is not so. Where communication between scientists is poor, effort is wasted on projects which have already been investigated. Lack of a common language is the greatest barrier to good communication, military secrecy exerting its restrictions in only a few very limited fields.

It would seem that abstracting papers published in other languages would aid in crossing such barriers. Abstracts are sufficient to tell the reader if the information will probably be of use to him, but in most instances if he wishes to make serious use of the material he must refer to the original paper for the details. The value of these abstracts is thus no more than that of abstracts of papers in his own language, since he still must translate or have translated papers which interest him, printed in other languages. *Chemical Abstracts*, for example, indexes papers which appear in several hundred different publications in more than twenty different languages. In some minor fields, comparable publications are less complete or lacking altogether.

Fortunately for the scientist who wishes to do his own translating of these papers, the vocabularies of science and engineering are small compared to those of history, literature, or even everyday conversation, and they contain a great number of "international words," words that have similar pronunciations and, where alphabets are similar, similar spellings in most of the world's major languages. Such words can not exist in an ideographic language like Chinese in which the basic symbol is the word, which is given a monosyllabic pronunciation. Most of the specialized words of science appear in similar identifiable forms in most of the Germanic and Romance languages and, to a lesser extent, in the other languages which use the Roman alphabet. For example:

English	factor	electric
French	facteur	électrique
Italian	fattore	elettrico
Spanish	factor	Eléctrico
German	Faktor	elektrisch
Russian	Faktor	elektrieckii
Roumanian	factor	electric

Unlike the words of the technical jargon, the linking words — the simple verbs, the prepositions and the pronouns, especially — used in technical literature are largely the same ones used in everyday writing and speaking and are by no means "international." Discovering what is being talked about in a technical paper is rather simple. Determining what is being said about it is another story. Once the basic vocabulary of a few hundred non-"international" linking words is acquired, technical literature in Romance languages does not present any great problem to the English speaking person. With German, in addition to the basic vocabulary (and a good German-English dictionary), a certain amount of skill at playing "find the verb" is required. Russian presents the added problem of learning a new alphabet, and learning Chinese is almost a career in itself, especially since it is devoid of "international" words.

Those who don't have a reading knowledge of all of the world's major languages must resort to translation services. But MIT's translation service, for example, does translation at a cost of two cents per word for the Germanic and Romance languages and two and one-half cents per word for others. Translation of the average article from a technical journal thus costs twenty-five to fifty dollars. Moreover, it might easily take several weeks or even months to get the requisite men and materials together to obtain a translation of an article from "Cellulose Industry," for example, which is printed in Japanese.

The value of abstracts as indexes of literature in a particular field is very much dependent upon the availability of the journals which are abstracted. A large collection of journals in the office not only looks impressive, but can also contain information of great value;

(*Continued on page 24*)

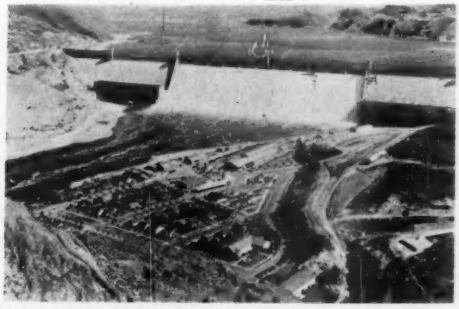
development of the pacific northwest

The Mighty Columbia Is Harnessed

By Howard F. Davis, '53

The Pacific Northwest, richly supplied with natural resources, has been setting a pace for development in the past fifty years. It still offers as much, and in most cases more potential for future development than any other region in the United States.

The term Pacific Northwest refers to the region consisting of Oregon, Washington, Idaho, and that part of Montana west of the Rocky Mountains. The region is vast in land area alone. A very great proportion



The Grand Coulee Dam in central Washington, the largest structure made by man.

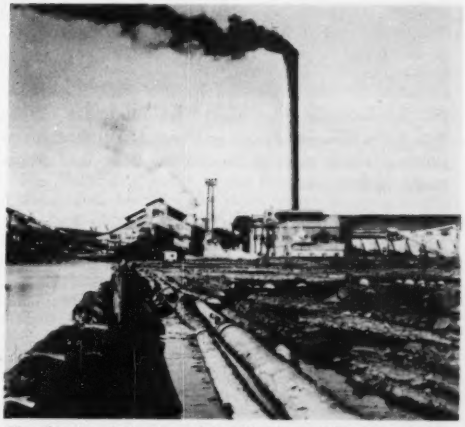
of the Northwest is drained by the Columbia River. The actual area is approximately 259,000 square miles.

It is very unusual to find as extensive a supply of fertile land and an abundance of water anywhere in the world as in the Pacific Northwest. But the lands through which the Columbia and its tributaries flow vary from the grazing and grain lands in the East to the dense forest of the mountains and the fertile valleys of the West. Oregon and Washington alone produce 10 per cent of the United States' wheat, over a third of its lumber, 25 per cent of its pulp, and nearly 30 per cent of its apples and pears. From this it is evident that this region has already made a place for itself as an important economic part of the United States, but more important is the fact that its potentialities of 1900 are far from yet being fully realized, e.g., manufacturing is still being attracted to this area because of the low price of electrical power. It is still growing.

The region is dependent, and is becoming more dependent, on electric power from hydroelectric sources because, unlike other regions in the United States, it does not have a supply of the natural fuels: coal, oil, and gas. The Northwest and the United States both obtain 40 per cent of their energy from gas and oil; however, the Northwest derives only 10 per cent of its energy from coal while over 50 per cent of the United States' energy comes from coal. Sixteen per cent of the Northwest's energy comes from wood while the amount of wood used by the United States as a whole is exceedingly small. Finally, the Northwest obtains 30 per cent of its energy from hydroelectric sources while the United States obtains only four per cent from this source.

When it was found that an ample supply of wood would not be available, the Northwest shifted to oil; however, hydroelectric plants are now displacing oil as an energy base. This shift was economically wise because the hydroelectric power was more accessible than the oil. The change was from dependence on non-replenishable resources to dependence on the always plentiful water supply. It is interesting to note that the lumbering industry was once the chief supplier of energy, while now it is one of the chief users of the hydroelectric energy supply.

The largest Federal dams are Bonneville and Grand Coulee, which are located on the Columbia. When Bonneville was put into operation in 1939 it had a potential that was more than that of the then four biggest dams in the Tennessee Valley Authority: Wilson, Norris, Wheeler and Pickwick Landing. Bonneville is a "low head" dam — its average head is 60 feet. It is one of a number of dams which are to provide for a navigable waterway 465 miles inland. The Army Engineers constructed it, and are responsible for its operation. Grand Coulee, being on an unnavigable part of the river, is used only for irrigation and hydroelectric power. It is estimated that Grand Coulee, when in full operation, will irrigate nearly one million acres of land, and have a power output of almost two million kilo-



The leading industry of the Northwest is paper manufacture. Here is a sawmill in central Oregon which turns the rough logs into the finished lumber.

watts. Because it will provide water for such a great area, and because of the nature of the terrain, it is by necessity a "high head" dam — its average head is 320 feet. The back waters from the dam extend north to the Canadian border. Grand Coulee was built by the Bureau of Reclamation, and is maintained by them.

(*Continued on page 10*)

The pacific northwest

(*Continued from page 9*)

Both of these dams, and most of the dams to be built are multipurpose; i.e., they provide for two or more of the following needs: irrigation, navigation, flood control, and hydroelectric power.

Because the large users of power are in most cases distant from the hydroelectric plants, it has been necessary to construct a great number of long transmission lines to all parts of the region. The 3,662 miles of lines make it the largest high voltage system in the United States; it operates at 230 KV and 115 KV. Together with the transmission system there is a distribution system consisting of 105 substations and switching stations; the total capacity is approximately 3½ million KVA.

The transmission lines cross high mountain ranges. This is the Cascade Range as viewed from Washington looking south toward Bonneville Dam and Mount Hood, in Oregon.

The basic industries in the Northwest before the advent of hydroelectric generation were fishing, lumbering, and agriculture. However, with the initial use of Bonneville Dam in 1939, and Grand Coulee Dam in 1940, industries began to move in. Numerous electro-processing industries have been attracted because of their need of large blocks of electric power, e.g., the Pacific Northwest accounts for half of the aluminum ingot output of the United States. Industries making chlorine, ferro-alloys, abrasives, electrolytic zinc, powdered iron, caustic soda, and calcium are being attracted.

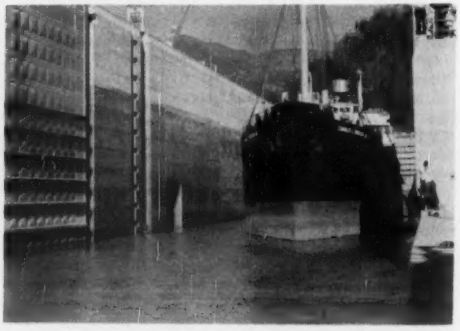
In 1946 Oregon and Washington used 14,400 KWH per worker in industry. This is a 68 per cent increase over their 1939 level. The United States increased very little in its use of KWH per worker over the 1939–1946 period; in 1946 the United States average was 5,760 KWH per worker.

The price of industrial power is uniform throughout the area, facilitating the decentralization of industry, a difficult problem in the modern city. The cost of electricity per KWH for industry in the Northwest in 1949 was well below one-half cent per KWH, while the cost per KWH for industry in the United States was nearly one cent.

Of course the population as well as industry is benefiting from the power developments. Seventy-eight per cent of the farms of the United States are electrified, but in the Northwest this is true of over 90 per cent. Because of the available cheap power 5,000 KWH are used per customer per year by farms and residents in the Northwest, but the United States as a whole has a rate of only 2,000 KWH per customer per year. In addition the Northwest customers pay on the average one and one-half cents per KWH while the national average is nearly three cents per KWH.

Through numerous technical developments the cost of transmission equipment per KW has remained essentially at the 1940 level. Lines which were planned to carry only 100,000 kilowatts per circuit are now carrying nearly twice that amount — 190,000 kilowatts. A number of other improvements in communications and relay controls have made possible the use of these higher voltages. Transformers which had been rated at 173,000 volts are now being used at 230,000 volts without lowering the safety to any dangerous degree. By using these transformers with less insulation than previously thought possible there is a great saving. Such operating conditions are being considered for new standards by AIEE and NEMA. In 1940 the largest transformer banks were rated at 100,000 kilowatts; however, at present, units up to 250,000 kilowatts are being installed. This in itself represents a great reduction in the cost of materials. Transformers placed in operation by Bonneville Power Administration cost only $3.80 per KW in 1949, but in 1940 the cost per KW was $7.25. Steel towers which use 30 per cent less material than the standard types were designed by B.P.A. engineers, resulting in a saving of approximately $8,000 per mile. Cables which will allow higher than the conventional voltages are being used, with the final result that there will be a saving of 20 per cent in dollars per kilowatt over older systems.

Prior to the Federal Dams most of the generation in this region was under control of private and public utilities. The private utilities, under the control of holding companies, produced 75 per cent of the total power (1,177,000 KW) in 1935 while the public utilities produced 24 per cent (372,000 KW) in the same year. The Federal projects produced only 20,000 KW in 1935.



The multipurpose dams make it possible for large seagoing vessels to travel more than two hundred miles up the Columbia from the Pacific Ocean, by deepening the river. These are the locks at Bonneville Dam one hundred and fifty miles up the Columbia.

From arid waste land to productive farm land by irrigation. The Pacific Northwest produces ten per cent of the nation's wheat supply.

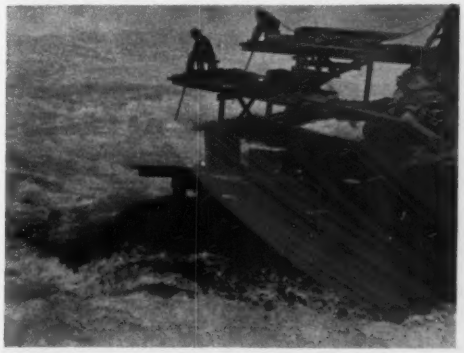
Before 1930 there was a move to support public power developments in Oregon and Washington in a reaction against the poor financial management and policies of the privately operated companies. As a result Public Utility Districts (PUD) were established. Each municipality had control of its district's distribution of power. Similar organizations performing many of the same functions as the PUD's were called Rural Electrification Areas (REA).

The Federal projects — Bonneville, Grand Coulee, and a few smaller projects on the Snake River — owned 48 per cent of the generating capacity in the region in 1949, and supplied 58 per cent of the 23.5 billion KWH produced in that year. Because of the demand for power during the war years a Northwest power pool was created; it consisted of tying in the Federal plants with eight private and two publicly owned plants. This pool, which helped relieve the power demand during and immediately after the war, is still in operation, and is now a 4,200,000 kilowatt system. It is anticipated by the Bonneville Power Administration that this Northwest pool will be the largest in the United States at the end of the decade.

McNary Dam on the Columbia is now under construction and will be generating power by 1953; its capacity is 910,000 KW. Chief Joseph Dam, also on the Columbia, according to present plans will be generating in 1956; its capacity is 1,280,000 KW. In Northern Montana Hungry Horse Dam, with a capacity of 285,000 KW, will be ready for generation in 1952. Together with these there are nine other dams which are either authorized or under construction on the Columbia and its tributaries at this time. The plans of a twenty-year program (1950–1970) are to bring the Federal developments in the area to 12 million kilowatts. It is planned to keep the flow of the lower Columbia to 800,000 cubic feet per second, as floods of 1,200,000 cubic feet per second have caused heavy damages in previous years. It is also planned to provide irrigation water for 2.3 million acres of arid land and to better supply 1.2 million acres of now insufficiently irrigated land, and to provide navigation to Lewiston, Idaho — 465 miles from the ocean.

The cost of the existing Federal developments is $550 million, and the future developments will amount to an expenditure of $200 to $230 million per year. These are well placed investments because at the present the revenue is $30 million per year, while the net income per year is $10 million. When the dams which have been projected for construction before 1970 are in operation, the annual revenue will be $200 million per year.

The Columbia River has 40 per cent of the undeveloped hydroelectric power in the United States. One reason for this is that it drops over a mile while flowing a distance of a thousand miles. By the present plans, calling for rapid development, only 12 million KW of the estimated potential 32 million KW of the Columbia and its tributaries will be harnessed by 1970. The Pacific Northwest is one of the fastest growing regions in the United States. For many years to come it will have room and resources to support an increasing number of people and industries.



Fishing is a basic industry on the Columbia and its tributaries; this is Celilo Falls on the Columbia.

Coming Next Month...

A Perfect Audio System will give a concrete plan for building an ideal sound reproduction device.

Buried Treasure Round the World will tell everything, with maps included. It also will explain why millions in gold *remain* buried.

Prefabs will show the possibilities and bugs in prefabricated housing. Why isn't there a cheap prefab house in every backyard?

Communism and Genetics will take the bull by the horns and show why Lysenko was all wet, or why he wasn't.

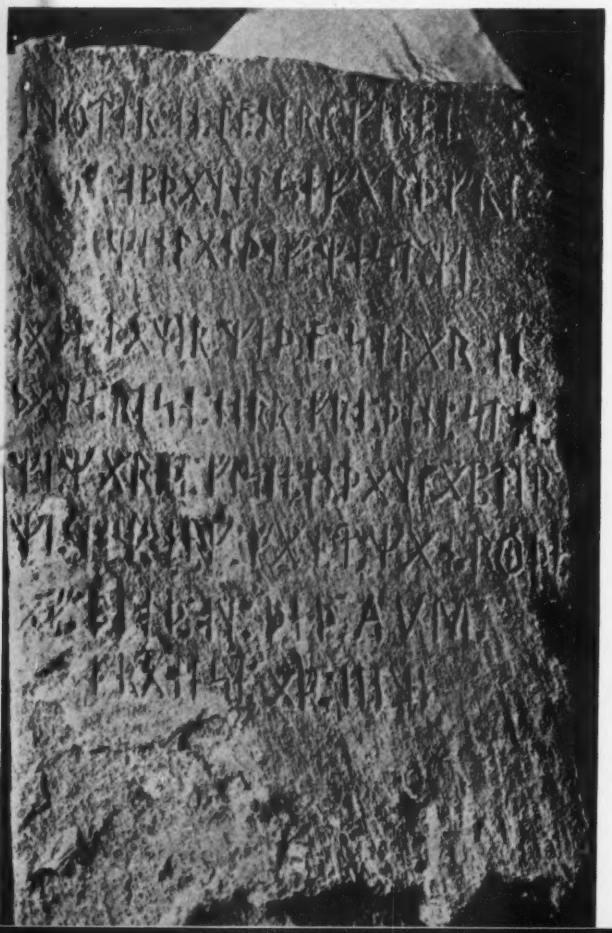
early norse discoveries

Evidence Indicates that the Norsemen Were in America in 1362

By Stanford R. Amstutz, '54

With the cooperation of Hjalmar R. Holand, author of "Westward from Vinland," and Duell, Sloan and Pearce, publishers thereof.

In the summer of 1898 a farmer in western Minnesota was engaged in clearing a portion of his farm of trees and underbrush. In the course of his labors this farmer, a Mr. Olaf Ohman, encountered a great deal of difficulty with a scrub aspen. All other methods failing, he finally dug completely around the tenacious aspen and discovered that its roots were wrapped about a good-sized stone of more or less rectangular shape. Temporarily abandoning this particular tree, the exasperated Mr. Ohman went to other work, but his son in playing about the root-entwined stone chanced to observe that one surface was covered with an inscription of some sort. Neither the father nor the son had ever seen characters resembling those in which the inscription was done. They therefore sent the stone to an authority of Scandinavian languages, who stated that the inscription had been done in Runic symbols but declared that it was a forgery and returned the stone to Mr. Ohman as such. The finder having no reason to question the decision of the professor, placed the stone in the front of his granary and used it as a doorstep.



Nine years after the discovery of the stone, which by this time had come to be known as the Kensington Stone after the village near which it was found, a Mr. Hjalmar R. Holand heard of the Kensington Stone's existence and asked Mr. Ohman to examine the stone for himself. Ohman consented and led Holand out to the granary where the Kensington Stone had lain for nine years. Even though the stone had been declared a forgery by an authority who certainly should have been correct, Holand desired to make his own translation. In view of this, he persuaded Ohman to give him the stone and in a short time was able to present the following translation. (Words enclosed in brackets were left out of the Runic text and have been added by Holand so as to make it grammatically correct when read in English. Words enclosed in parentheses are words of explanation which give meanings implied in the Runic text but which are not evident in the English text.)

1. [We are] 8 Goths (Swedes) and 22 Norwegians on
2. [an] exploration-journey from
3. Vinland through (or across) the West (i.e. round about the West)
4. We had a camp by [a lake with] 2 skerries one
5. day-journey north from this stone
6. We were [out] and fished one day After
7. we came home [we] found 10 [of our] men red
8. with blood and dead AV[e] M[aria]
9. Save us from evil

And on the edge of the Kensington Stone was the further inscription:

10. [We] have 10 of [our party] by the sea to look
11. after our ships (or ship) 14 days journey
12. from this island [in the] year [of our Lord] 1362

At first glance, to even entertain the thought that there were Scandinavians in Minnesota in the year 1362 seems absolutely absurd. Only recently have authorities admitted that the Norse landed before Columbus. And now to suggest that they traversed inland as far as Minnesota is almost beyond conception. But before we make any dogmatic statements, let's examine all of the evidence relevant to the Kensington Stone which Mr. Holand has collected.

In the beginning of his investigation, Holand had but two sources of information: the stone itself and the conditions under which it was found. You will recall that the Kensington Stone was discovered with the roots of a tree wrapped about it. These roots were flattened on the side toward the rock so that we can safely assume that the rock was beneath the tree during the entire life of the tree. But just how old was the tree? Holand conducted an exhaustive study on the

The Kensington Stone, relic of a heroic and tragic wandering of the early Norsemen on our continent nearly six hundred years ago.

growth of aspen trees in the United States. He based his final decision principally on the reports concerning aspen trees of several botanical societies of the United States. Taking into consideration the size of the tree found over the Kensington Stone, its stunted growth due, no doubt, to the rock beneath it, the general characteristics of aspens, and the amount of rainfall which would have fallen on the tree during its lifetime; Holand fixed the lifetime of the tree as being not less than seventy years.

But before we go further, let us consider another aspect influencing the history of the rock. The effect of weathering on the stone and its inscription was carefully studied by prominent geologists of the world, and

Two extremely similar axes which lend authority to the Norse theory. The upper one was found in Michigan, while the lower one is to be seen in the Lillehammer Museum, Norway.

they definitely stated that the rock had been exposed to the elements for a period of at least one hundred years prior to the time when it must have fallen over. If we temporarily assume that the inscription was a forgery, these two facts mentioned above fix the date of our supposed forgery at 1726. Another fact worthy of brief consideration is the necessity for the rock to have had at least a covering of soil in order for the seed of the aspen to have taken root. The deposition of a layer of topsoil is an extremely slow process, and we are certainly underestimating the time necessary if we put the time of the planting of the forgery back another twenty-six years to 1700.

In view of this evidence, if we are still to cling to the possibility of a forgery, we must imagine the forger coming to Western Minnesota sometime around 1700. For the period of two to three days when he would be engaged in making the inscription, his life would constantly be in danger, since at this time Western Minnesota was the territory of the extremely hostile Sioux Indians. He must have been an unusual man having at his command a goodly amount of abstruse knowledge of Runic symbols and words, and also have been a man of great courage and experience with the wilderness which would permit him to go far afield from the last outpost of civilization. More than this, as far as we can see, he was without motive for such an undertaking. Even though all archaeological forgeries are meant to be found, our scholarly forger could scarcely believe that his forgery would be found in the middle of a trackless wilderness populated by hostile Indians. An analysis of these facts makes a forgery appear highly improbable.

Having virtually established the authenticity of the Kensington Stone, Holand's next question was, precisely who was the worker who made the inscription? He concluded that if the inscription on the Kensington Stone had indeed been done by a Norse explorer in 1362, there might be some record in Norse history of a party of explorers leaving the Norse countries about this time. Soon he remembered the Paul Knutson expedition.

In 1354 King Magnus Erikson, joint king of both Sweden and Norway, being a zealous Catholic, was much concerned when he learned that some of his subjects living on the western coast of Greenland had renounced Christianity. In order to rectify this mortal sin, he commissioned one Paul Knutson to lead a missionary party, to be composed of men of the retinue of King Magnus and of men of the retinues of other princes, whose purpose was to rechristianize the wayward settlers of Western Greenland. They embarked in 1355 and returned in 1364. Here our knowledge of the Paul Knutson expedition ends; at least the knowledge supplied by Norse history ends here. However we may conceivably complete the story of the Paul Knutson expedition by means of shrewd guesses based on circumstantial evidence and also by means of the narrative given on the Kensington Stone. Let us follow the processes of reasoning which led Mr. Holand to believe that the party which inscribed a stone in Western Minnesota in 1362 was a remnant of the Paul Knutson party.

What follows is admittedly conjecture. However, as mentioned before, these will be guesses based on circumstantial evidence; guesses which give the most logical explanation as to what probably happened. According to the Norse history, the Paul Knutson expedition left the domain of King Magnus in 1355 and returned in 1364. If we take this at face value, it means that these men spent nine years on the desolate Western coast of Greenland. This is highly unlikely. Beyond this, many historians are agreed that the un-Christian settlers had left Greenland by the time Knutson got there. If such was the case, Knutson's missionary party must have followed the settlers to their new home, and home had to be somewhere in the West. There they would not only escape the wrath of King Magnus but they might find a congenial climate and a permanent home in Leif Erickson's Vinland. But where was Vinland? It had been many years since Leif Erickson had lived and by this time the exact location of Vinland was unknown. And so when the missionary party reached the mainland of what is now North America, they probably began to sail along the coast, examining every inlet in the hope of finding the itinerant settlers. They may well have reasoned among themselves that they would sail completely around this island if necessary in their quest for the settlers, accomplishing something in the way of exploration as well as Christianization. (All of the early Norse explorers thought that the land on which Vinland was located was

(*Continued next page*)

early norse discoveries

(*Continued from page 13*)

merely another large island.) Constantly seeking the settlers, they eventually came to Hudson Bay and felt correct in thinking the land to be an island for now they went south for several hundred miles. Eventually they must have come to the Nelson River which is larger than any in Europe and would convince them that they were not following the shores of an island but of a continent. They had now traveled hundreds of miles seeking the settlers and had not found any trace of them. Is it not conceivable to suppose that the Knutson party abandoned hope of finding the settlers at this point and instead decided to find just what the interior of this continent looked like? We must not forget the

Here are some mooring stones found on the shore of Cormorant Lake. The pegs show the positions of holes made by the Norse for iron pins.

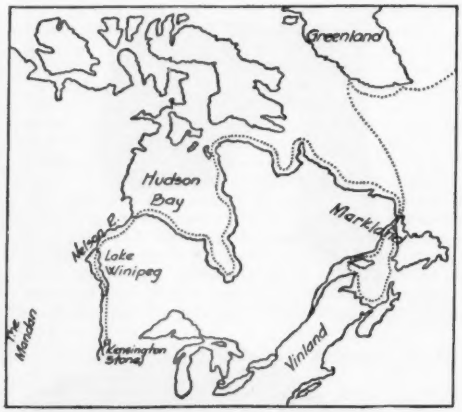
Photo by Esther Henderson

great spirit of exploration which permeated these old Norsemen. And so they started inland on a journey which perhaps would not be so spiritually rewarding as a missionary trip but in its own right would bring much satisfaction here on earth.

From this point on we can depend upon the Kensington Stone for our narrative. However, before we go further, let us answer a question which will undoubtedly arise. How can we be sure that those people who inscribed the Kensington Stone did not come down the St. Lawrence River? You will remember that the three lines of inscription on the side of the Kensington Stone read as follows:

10. We have 10 of our party by the sea to look
11. after our ships (or ship) 14 days journey
12. from this island In the year of our Lord 1362

Our decision that they came down to the southern end of Hudson Bay before embarking overland depends upon two parts of this section of the inscription. The word sea which appears in the inscription is used, according to Mr. Holand, only when referring to a body of salt water. If they had come down to one of the Great Lakes by way of the St. Lawrence River before embarking, they certainly would not have referred to the particular lake from which they left as a body of salt water. However the word sea does apply quite



The route of the explorers down the Hudson Bay.

well to Hudson Bay which is of course salt water. The other basis for assuming the voyagers to have come by way of Hudson Bay is the statement on the Kensington Stone that the ships were left fourteen days journey from the Stone. As will be elucidated below, a day's journey is a measure of distance, so that fourteen days' journey represents a distance of about one thousand miles. It is almost precisely this distance from Kensington to the mouth of the Nelson River, but is considerably more or considerably less a distance to any of the conceivable points of embarkation on the Great Lakes. Now then, if we can, let us reconstruct the journeys of the Kensington party from Hudson Bay on. As is stated on the Kensington Stone: "We had a camp by a lake with two skerries one day-journey from this island. We were out and fished one day. After we came home we found 10 of our men red with blood and dead." Manifestly we have here the account of a massacre. The memory of the shock is still so vivid in the inscriber's mind several days later, that he still describes the event just as the facts became known to him. First they returned to camp and found their comrades' heads covered with blood, probably scalped, and then on closer examination, they saw that they were dead. Then the eight Goths and twenty-two Norwegians still remaining in the party fled this unknown band of enemies, not stopping until they were one day's journey distant from the scene of the massacre, where they felt they could safely inscribe a last memorial to their dead comrades.

(*Continued on page 28*)

functions, operators, and the fourth dimension

An Invitation to Mathematics

By Harry F. Davis, G.

No amount of propaganda can make a Tech man want to abandon his study of science or engineering to take up art or music as a career, if he has not previously had a deep desire to create art or music. The situation is the same with mathematics, except that mathematics, although an art, is one with which he already has a certain familiarity. Although mathematics is not basically a useful subject, and by itself is unable to contribute anything new to our understanding of the physical world, it is essential to our reasoning about the physical world. It is important, therefore, that the engineer or scientist have a working knowledge of those parts of mathematics that may apply to his work, and some perspective on how those parts of mathematics fit into the entire framework of the art. It is also important to have students training in mathematics itself, to enrich the field with further creative effort. This article is an invitation to mathematics, the nature of the invitation to be clarified in later paragraphs. In closing this paragraph we emphasize that, if the reader should ever decide to become a mathematician, he will find, at that time, that really he made the decision long ago.

At the same time that a teacher tells his students that mathematics is an object of elegance and beauty, he forces them to find the length of one arch of an epicycloid, or to sketch the curve corresponding to some preposterous equation. Even if he realizes the absurdity being committed, he can only tell the disgusted class that math gets more satisfying on a higher level. This is like the poor dilettante who has hung about his house a collection of the ugliest possible paintings, but who assures the neighbors that a magnificent Rembrandt hangs in the locked closet. The inconsistency is apparent to the bored student, who is appalled that anyone could spend a lifetime working in such a field, and who knows that there are no financial returns to make up for it.

The main object in the teaching of calculus seems that of replacing understanding by problem solving technique, on the theory that, after all, you can't really expect a freshman to understand a subject that took a thousand years to develop. We laugh at the thought that a small child, once told the meaning of a five-syllable word, should be expected to use it properly in conversation. Yet we require our freshmen to use, without understanding, a few basic concepts, that there would be plenty of time to teach but for the multitude of applications. We replace the basic ideas and principles with drill problems using standard formulas. Is it surprising, then, that most students at Tech are unaware that research continues in mathematics, that this field too has had its "atomic" developments in recent years?

Whether anything can, or should, be done about the teaching of mathematics, this much is indisputable: most teaching of mathematics does not constitute an invitation to mathematics, for the reason that it is so far from being modern mathematics. The rest of this article is devoted to a few very simple, abstract concepts that can easily be understood by a sophomore (possibly a freshman), and may give some inkling to the interested reader of what is meant by "structure" and "abstraction" in mathematics, words which are often used but rarely explained. I hope that the reader will consider these subjects both as an interesting recreation and as an introduction to a few ideas which are important in modern mathematics.

Concept of a Function

We all know what a function is. An example is $y = x^2$. It can be thought of as a rule that assigns to a number, such as 5, another number, 25, and we say $f(5) = 25$. Has it occurred to you that is really a more general notion than this? For example, we might have a rule that assigns a number to each letter of the alphabet, in the manner of a Little Orphan Annie Secret Code Pin. Of what value is such a concept? One possible use for it is for enciphering secret messages, where only a low level of security is desired. We will use it here for a more interesting purpose, to get a better idea of what a function is.

Let's be sure we understand the idea: A rule must be given, which assigns to each letter a certain number. For simplicity, let us not use the whole alphabet, but only the four letters *a,b,c,* and *d*. These four letters constitute the "domain" of the function. That is, if the function is denoted $f(x)$, x can "take on" the values *a,b,c,* or *d*. Thus one such function might be $f(a) = 1$, $f(b) = 2$, $f(c) = 3$, $f(d) = 4$. Another function might be $g(a) = 3$, $g(b) = 5$, $g(c) = 7$, $g(d) = 9$. Notice that while the *domain* of this kind of function consists of the four letters *a,b,c,d*, we allow the function to have numerical *values*, just like the functions of M11.

Just as heat is sometimes defined as energy in transit, so too we define mathematics as the study of *ideas in transit*. The dominant attitude of modern thought, in many fields, is this dynamic approach; we are rarely interested in constructs as such, but in the logical relation between constructs. Thus we do not care so much about the functions mentioned, as in their relationship to each other and to other functions. Nor are we interested only in functions $f(x)$ where x can vary over four letters, but in all functions $f(x)$ where x can vary over any specified collection of objects, and where the "value" of $f(x)$ can also be articles in any collection. Mathematics is concerned with the relations between ideas. If we think of ideas as balls floating around in space, we think of the *idea structure* as the bones which connect certain balls together. The rules whereby we form these connections are the so-called rules of logic. In a sense mathematics is more practical than the study of logic, for mathematics stands willing to build a structure on any reasonable set of logical rules.

The Operator Concept

In the example just given, we are not so much interested in f and g separately as in the relationship $g(x) = 2f(x) + 1$. The reader will verify that this is a rule which enables us to find the function g when we are told the function f. Yet, eureka! This is also a function! That is, we now have a rule, $g = 2f + 1$, which

(*Continued on page 26*)

industrial

Some Modern Laboratories

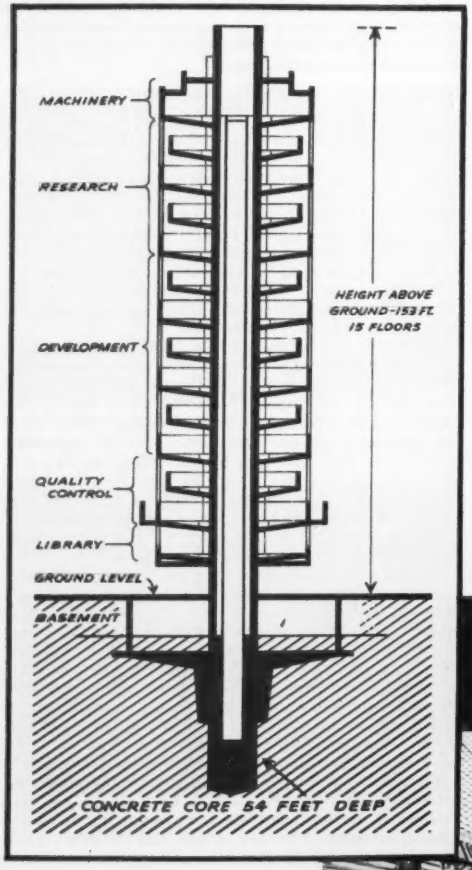
By the

In keeping with their recognition of the importance of research to ultimate profit, the large industries of the United States are expanding their research programs in an impressive way. We say "ultimate profits" because industry has learned the necessity of delving into apparently sterile fields in order to progress in the diversity and value of the products it makes.

Particularly, some of the expansion takes the form of new or improved laboratory facilities, depicted on these pages. Probably the major impetus to lab building is the post-war boom, which has provided swollen profits for basic industry to sink into its improvement.

But from these pictures it is seen that the new temples of science are not nightmares of poor designing. The research staffs of the companies concerned have taken active part in the designing of facilities for maximum utility. Such a development is heartening, though we may expect that shiny and compact apparatus will lure some of our professors into industrial research! It has done so before; for instance, Dr. Willis R. Whitney became the first Director of General Electric Research Laboratory at the turn of the century. Up to that time, he was a Professor of Chemistry at the Institute.

Let's take a look at some of the labs. First on the list is the so-called Johnson Tower, a newly constructed lab of the S. C. Johnson & Son, Inc., wax manufacturers. Designed by Frank Lloyd Wright, the Tower may be expected to exhibit originality. It does, as a glance at the illustrations shows. It was created as space for research, development, and quality control, and only temporarily serves as a World's Fair-like showpiece. Outstanding from the architectural viewpoint is the central shaft support of the floors. All the weight of the building, some eight thousand tons, is supported cantileverwise from a concrete core only thirteen feet wide at its narrowest. Every other floor is circular, and the walls are of two-inch glass tubing.



S. C. Johnson and Sons, Inc.

A modern laboratory from the hand of Frank Lloyd Wright. Essentially just a concrete pole sunk into the ground, the *Johnson Tower's* floors are supported by cantilever construction. Note that alternating floors are in the form of circles, concealed from exterior view.

The sunlighted laboratory in the *Johnson Tower*. The walls are of two-inch glass tubing, a construction made possible by cantilever support of the building weight. Note the spacious work areas and storage facilities.

S. C. Johnson and Sons, Inc.

Most striking, however, is the fact that the technical staff of the laboratory specified completely the internal arrangements. Every blueprint had to be signed by a member of the "Tower Committee" — a group of research men. According to Wright, the lab was "designed to be as inspiring to live in and work in as any cathedral was to worship in." Inspiring, maybe; certainly spacious, well-lighted, and useful.

Not so modern, but on a grander scale, is the

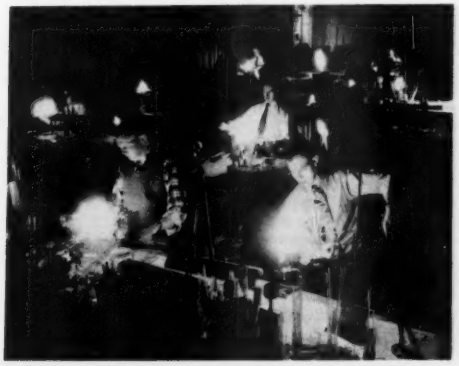
research

in Industry

T.E.N. Staff

thirteen-year-old Armour Research Foundation, which employs no fewer than six hundred and fifty technical personnel. Started in Chicago, the Foundation operates on a nonprofit system called the "Armour Plan." Companies engage the Foundation on a contract basis for specific research projects. Last year A.R.F. worked on three hundred projects, at a total cost of four million dollars.

Work is really booming in physics, metallurgy, chemistry, applied mechanics, electrical engineering, and ceramics. But rigid departmentalization is unheard of in the pursuit of a problem at this huge lab. The idea is to unify specialties into a team. This definitely characterizes all modern large-scale research; it may be



The General Electric Company

Among the facilities of GE's new lab is this modern glass-blowing shop. Also available for research are the facilities of extensive machine shops, a helium liquefier, and modern synchrotron atom smashers.

said that the idea of productive efficiency has reached to the most individualistic of creative endeavors — scientific thinking.

General Electric is of course no newcomer to the field of industrial research — in fact it was the first, back in 1900. But in October, 1950, a new GE Laboratory was dedicated, and it too is a model of enlightened planning. Witness the inclusion of removable steel panels, which make available spaces ranging from six feet to building length in width. It is a handsome

The General Electric Company

The new home of the GE labs located at the Knolls, near Schenectady. The main building of the laboratory, it has two floors below the level of the ground. Unique is the *free-space* concept of design, which provides movable steel partitions for making working space of any desired size.

structure all right, and will serve well to reaffirm the position of the GE Lab as one of the top ones in the country.

The special contribution of GE was to early realize the value of seemingly inapplicable research. Elihu Thompson, the great electrical engineer; Charles Steinmetz, the originator of alternating current theory; William Coolidge, an M. I. T. man who invented the modern X-ray tube; Irving Langmuir, the recent researcher into rainmaking; Albert Hull, worker in electron tubes — all these men worked freely on their own pet ideas in the GE Lab. Needless to say, profitable enterprises were the result of much of the research there. And the lab is carrying on the tradition; they are among the few to experiment with fundamental nuclear problems.

We appreciate the help of *Industrial Laboratories*, a new monthly devoted to the blossoming field of industrial research; all photographs are by the courtesy of that journal.

Metallurgy is an important area of research at ARF. Here scientists evaluate the temperature of oxygen-blasted molten steel by the use of an optical pyrometer. The laboratory boasts extensive equipment for small-scale foundry operations.

The Armour Research Foundation

tech engineering news

Professional Journal of the Undergraduates of the
Massachusetts Institute of Technology

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from the editor's notebook

What We Want . . .

Today is February 11, 1951. It is two days after an ad appeared in *The Tech* exhorting the students of M. I. T. to throw their weight in favor of a program purportedly opposed by Dr. Killian, President of the Institute. I cannot here discuss the pros and cons of this issue, for it is the sorry fortune of this sheet to have a five-week lag between writing and publication. Instead, I wish to point out that the very existence of the ad was a surprise to many, for it asked us, as students of M. I. T., to take a stand. We are not accustomed to take a stand. Let me try and show this.

There are three issues now abroad which are mentioned only a little in private, and not at all in public by the students of M. I. T. Yet they concern us as much as anyone. They are:

1. The loyalty oath at the University of California, which threatens to destroy the entity of a very good faculty. There is now before the legislature of the Commonwealth of Massachusetts a certain Bill 743 which will revoke the charter of any educational institution having a Communist on its staff. This bill is like one which was defeated last year by the efforts of school heads and the N.S.A., among others.
2. The strong movement afoot to form unions for the nation's half million engineers, of which you will be one soon.
3. The effect of the national emergency on scientists and engineers. There is little public opinion crystallized on the campus on the question of how the United States should best use her resources of trained and potential technical personnel.

Why aren't the students of M. I. T. concerned and articulate about these and other critical issues? More generally, why is there so little public discussion and so little organized movement to *bring about the things we want?*

I suggest that it is because we don't want anything we haven't got. That the status of the scientist and the engineer is settled as far as we are concerned. That the universal plan of action for the men in training at this school is to go to work for a big corporation. That we want only security and we know we can get it there. That the thought of Westinghouse hiring three hundred engineers this year to achieve security and anonymity in their vast technical program is the backbone of our personal philosophies of existence.

Why do we not come right out and admit that we will be the lackeys of anybody who will treat us nicely, or who will provide a womblike existence in return for a few problems solved, and stop pretending that we are intelligent and independent souls in search of the worth while and satisfying life?

There are indications of even deeper questions concerning our place in society, the worth of what we are doing, and the means of achieving our goals. I believe so; *T. E. N.* will attempt to place before its readers in the future a critical analysis by men who have thought along these lines.

G. B. F.

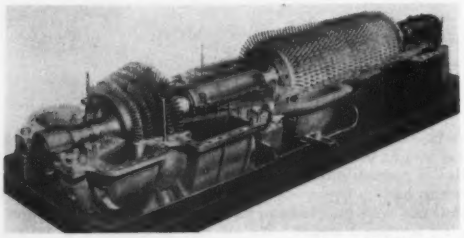
Who's Who in March . . .

There are two **Davises** represented this month, **H. F.** and **H. F.**! **Howard** is a Sophomore studying Electrical Engineering. He plans to make a career for himself in the Northwest power developments of which he writes. **Harry** is probably known to some as an instructor in math, to others as a grad student in XVIII. The validity of what he has written here is enhanced by his own personal story, as he himself was wooed away from the study of physics to that of math. **Ralph Johnston** and **Jacob Bartas** are doing graduate work in the M. E. department on the subject of engines, gas turbines and otherwise. Ralph is a former G. M. of this periodical. **Stanford Amstutz** takes an interest in things historical. A Freshman, he can tell you with some accuracy exactly what happened at the Battle of Gettysburg, even though he hails from Ohio. **James Stuart** claims his prime problem is too much interest in everything. A Senior in mathematics, he furthered his interest in semantics by taking Bodmer's course L71, entitled *Social Linguistics*. The ideas expressed herein are in part an outgrowth of his findings there.

gas turbines

(*Continued from page 7*)

rated a modified CBT cycle in its first Houdry catalytic cracking tower for making high octane gasoline. In the Houdry process it is necessary to blow large quantities of air through the cracking tower to regenerate the catalyst. After passing through the tower, the air is at about 1000°F. and can be used to operate a turbine to drive the compressor furnishing the air. A cracking



Mechanical Engineering

View of one of the Houdry unit turbines with casing removed.

unit of 10,000 barrels per day requires an air flow of some 40,000 cu. ft. per min. for regeneration, and operation has shown that with such a flow the turbine can not only run the necessary compressor but can also drive a generator to produce about 900 kw of electricity. Since the construction of the first Houdry process unit by Brown-Boveri about twenty-five additional installations have been made. The Sun Oil Company, which operates six of the units, has reported that the turbines were available for work about 98 per cent of their installed time, a tribute to the reliability of the units. The lost time, moreover, was mostly caused by inadequate bearing design — a fault corrected on subsequent units.

For developments after the Houdry applications we must turn our attention to Switzerland, or more specifically, to the three leading Swiss firms of Brown-Boveri, Escher Wyss, and Sulzer. Each of the firms had been active in the power field for some time and the economic climate of Switzerland long ago forced them into the gas turbine field.

Switzerland is commonly considered as being in an excellent position for the production of hydroelectric power. In warmer weather, when many mountain streams are active, hydraulic energy is abundant to be sure, but in winter many parts of the country suffer from water shortages and the hydro-electric plants can operate at only a very reduced capacity. Therefore, it is necessary for the Swiss to build alternate generating facilities to maintain the normal load in the winter months.

Three types of power plants are available for the job: Diesel engines, steam turbines, and gas turbines. The following table taken from data in *Power* magazine compares the economics of the three alternatives for a Swiss winter station operating with an average atmospheric temperature of 32°F.

	Diesel	*Steam Turbine*	*Gas Turbine*
Output, kw	50,000	50,000	50,000
No. of units	10 x 5,000	2 x 25,000	2 x 25,000
Capital cost, $/kw	65	43	33
Fuel	Diesel Oil	Coal	Bunker C Oil
Specific fuel cons. (lb. fuel/kw. hr.)	0.515	0.91	0.55

Coupled with the above operating figures are the relative prices of the fuel per pound.

	Per Cent
Bunker C Oil	100
Coal	120
Diesel Oil	173

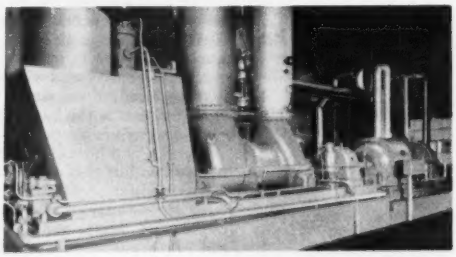
It can thus be seen that the development of the gas turbine in Switzerland was no unusual occurrence.

The first gas turbine designed specifically for power generation was built by Brown-Boveri and installed at Neuchatel, Switzerland, in 1939. A simple CBT cycle, the unit had a rated output of 4000 kw. The Neuchatel generator is still in operation.

The second commercial gas turbine power installation to begin service was a 2000 kw closed cycle turbine built by Escher Wyss. First operated in 1939, the cycle was fairly complicated, having a CICICBTTX configuration. The circulating air was heated in an oil-fired furnace. The unit reached a maximum efficiency of 31.6 per cent with a turbine inlet temperature of 1300°F., an ambitious figure for 1939.

A further indication of the state of Swiss turbine technology is the fact that a Brown-Boveri oil-fired gas turbine locomotive of 2500 horsepower went into experimental service with the Swiss Federated Railways in 1940.

The Swiss continued the development of their turbines throughout the last war although turbine production was virtually stopped by the military action which surrounded their country. Since the war all the firms mentioned earlier have been producing many turbines for export. As indicative of their output one may take the following three units: Brown-Boveri — a 27,000 kw turbine, CCICICBTBTX open cycle of 34 per cent efficiency for Beznau, Switzerland; Sulzer — a semi-closed cycle 20,000 kw turbine somewhat simpler than the Brown-Boveri unit with a 30 per cent efficiency at



Allis-Chalmers

A 6000 cfm Houdry process gas turbine unit.

a turbine inlet temperature of 1200°F.; Escher Wyss — a 25,000 kw closed cycle unit with an efficiency of 37 per cent at full load. A remarkable feature of the Escher Wyss turbine is its small size. With air heaters the entire generating plant occupies a space 100 x 40 x 50 feet. Without the heaters only 100 x 50 x 16 feet is needed. The apparent complication of the many components in the Swiss turbines comes from the fact that in turbines, as in many other products, the Swiss have standardized their production into a relatively small number of models of components. They are thus able to produce installations of many types and capacities by figuratively taking components off the shelf and assembling them to give the required output.

In contrast to the Swiss developments, the work in

(*Continued on page 22*)

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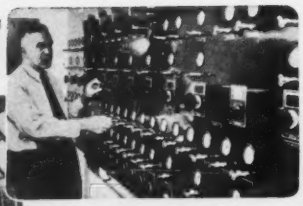
It seemed like a miracle to our grandparents and great-grandparents. Yet today, the telephone is a part of our everyday living. And that is the real miracle — the fact that the telephone has come to mean so much to so many people in so many ways.

The telephone is an indispensable tool of business and government — today's tremendous job of production and defense could not be carried on without it. It serves in minor emergencies and great ones. It helps maintain family and community ties. And it keeps right on growing and improving.

Never in the history of the telephone has it been so valuable to so many people as right now.

BELL TELEPHONE SYSTEM



Dr. Fritz Went at Control Board of the Plant Laboratory

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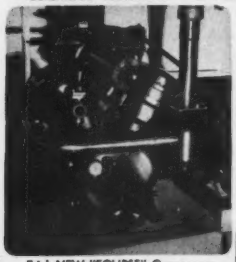

Frick NEW "ECLIPSE" Compressor at the Phytotron

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gas turbines

(*Continued from page 20*)

the United States in the gas turbine power field has not been very advanced. The lag in turbine development here was largely caused by the American economic picture — coal had been so cheap in the United States that gas turbines could not compete with conventional steam turbine plants. Since the war, however, economic conditions have changed somewhat and the characteristics of gas turbines have become better known with the result that turbine applications are growing in number.

The first major gas turbine development in this country after the Houdry process units were two turbines built for the Navy in 1943. One was built by the Allis-Chalmers Corporation, the other by the Elliott Company. Both turbines were built essentially as experimental devices for investigating the possible marine applications of gas turbines. The lessons learned from the two turbines, however, have been applied to commercial designs.

The Elliott turbine was a CICBTBTX cycle designed to produce 2500 horsepower with a turbine inlet temperature of 1250°F. The Elliott design was unusual in that it employed a Lysholm compressor, a rotary compressor which by its unique design delivers air at an almost constant outlet pressure regardless of operating speed.

The Allis-Chalmers turbine was a $\frac{BT}{BT}$ X cycle — one in which the two burner-turbine units were connected in a parallel arrangement instead of the usual series configuration. The turbine was designed to withstand a 1500°F. inlet temperature, but for experimental purposes the unit was first operated at 1300°F., the temperature being increased in steps to the 1500°F. design point. Operation at 1500°F. has yielded 3500 horsepower at 40 per cent efficiency.

The first commercial generating unit in this country was built in 1948 by the General Electric Co. for the Oklahoma Gas and Electric Co. A CBT cycle with precooling to lower the compressor inlet temperature, the installation uses cheap natural gas for fuel. Power output is 3500 kw with 80°F. inlet temperature and 5000 kw with 40°F. inlet. The turbine operating temperature is 1160°F. After installation the owner found that by piping the turbine exhaust gases into the feedwater heaters of the existing steam turbine plant an additional 2500 kw increase in output could be realized.

General Electric has continued in the gas turbine field with two types of units. The first is a 4000 kw CBT cycle, the first of which was installed in 1949 at Farmington, Maine, by the Central Maine Power Co. Occupying a space of only 45 x 10 x 10 feet, the unit runs at an efficiency of 17 per cent. The low efficiency is the result of the lack of regeneration. The Maine installation was, however, intended for standby service where capital cost considerations often outweigh operating economies.

Second type of GE turbine is a 6000 kw CICBTTX cycle with an efficiency of 28 per cent and a space requirement of 50 x 28 x 18 feet. The first of this type was purchased in 1949 by the Bangor Electric Co.

The growing acceptance of the gas turbine is evidenced by the fact that at the beginning of last year GE had eight additional commercial generating units on order. Five of the eight were for New England installations. At that time the company expected to sell ten more units in New England alone in 1950.

Thus it can be seen that despite a late start the use of gas turbines for power generation is moving ahead rapidly. As the characteristics of the machine become better known it can be expected that the turbine will meet with increasing acceptance.

As evidenced by the Oklahoma installation, areas where natural gas is plentiful are inviting locations for gas turbine power plants. Another attractive innovation is the use of gas turbines in the recovery of waste heat from the exhaust gases of existing steam plants. With flue gases as the heating medium either a closed or open cycle turbine might be run.

There exist still further untried or as yet unconceived specialty jobs for the gas turbine in the industrial field. As an interesting example one may consider the operation of a steel mill blast furnace. Blast furnaces require large quantities of air for the reducing reaction. The gases which leave the top of a blast furnace are combustible and are now burned beneath boilers to produce steam to drive steam turbines which power the compressors providing the blast furnace air. How much simpler would be the direct combustion of the gas in a gas turbine!

Probably the most promising new fields for the gas turbine will open with the development of techniques for burning coal directly in the turbine unit. When the turbine has been taught to digest coal and when metallurgical advancements allow the reliable use of sustained high operating temperatures with resulting high efficiencies, the steam turbine will be on the defensive.

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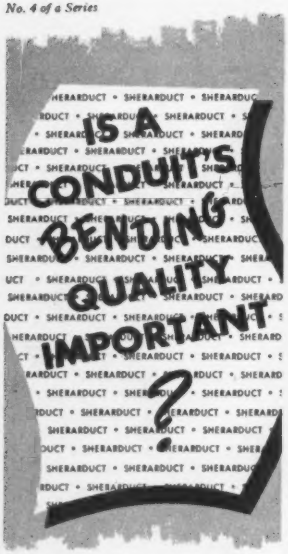

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a language for science (*Continued from page 8*)

therefore it is worthwhile to examine the major elements of their cost of production. Typesetting is the main factor in the cost of any literature printed in small quantities. This means that cost per copy can be reduced significantly by increasing the number of copies printed. Use of a single, generally understood language in all technical journals throughout the world would not only reduce the number of languages which the scientist would have to learn to one (by itself sufficient justification for such a move), but also would greatly widen the market for these journals, thus reducing their cost and thereby permitting an individual to purchase five or six journals for the present price of three.

Obviously, this situation calls for the adoption of a standard language for use in the world of science, not only for economic reasons but also to alleviate the increasing burden of language studies on the technical student. Because the same difficulties occur in even more acute forms for the social scientist, the businessman and the diplomat, the language adopted should be one that could also meet their needs. In effect, it should be one with a full general vocabulary capable of describing any materials, processes or events which come "in the ken of man."

Topping the list of required characteristics of such a language is that it be acceptable to the governments of the people of China, Great Britain, USA, USSR and most of the other major nations. If these governments reject the language by not teaching it in their schools, they can prevent it from being a truly international language. If they accept and support it, they can exert sufficient political and economic pressure on the rest of the world to insure its universal adoption as an auxiliary language. Nationalism is much too prevalent to permit any possibility of replacing national languages by an international one in the foreseeable future, even if the practical problems could be surmounted. International communication only would be the purpose and major use of the "interlanguage."

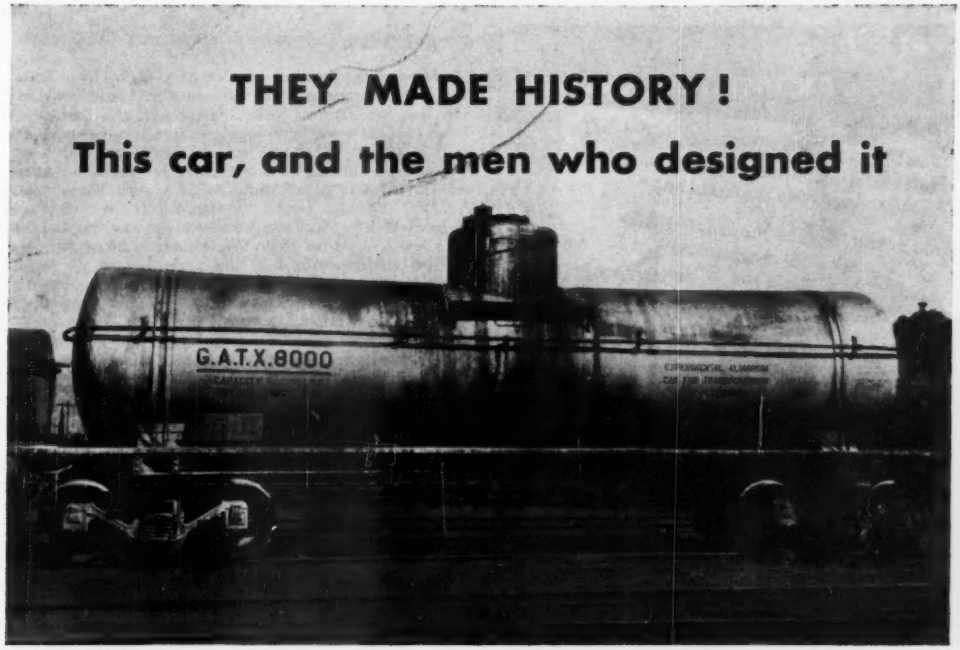
To be practical, the interlanguage should be one that is easy to learn and easy to adopt. The latter requirement would best be met by a language which uses the Latin alphabet without accented letters since printing facilities for it are much more widespread than for any other alphabet.

Anyone who has had to learn English will be quick to suggest phonetic spelling as a desirable characteristic for ease of learning — remember Shaw's classic spelling of "fish" — "Ghoti" from enough, women and notion? Ideally, there should be a single sound value for each letter or letter combination and no two ways of representing the same sound, so that if you know the standard pronunciation, you know the spelling automatically, and vice versa.

He who has suffered through any of the other European languages will undoubtedly recommend omission of gender of nouns and modifiers — no more straining over the question of whether inertia is masculine or feminine, and no irregular verbs. Simplicity and regularity should be introduced wherever possible to make learning, and especially writing, as easy as possible. In line with this, a uniform means of forming verbs, nouns, adjectives and adverbs from the basic root would be desirable — i.e. if: excite, exciting, excitement, excitation, excitable, then: scare, scaring, scarement, scaration, scarable.

From a strictly linguistic point of view, there is considerable controversy as to whether the interlanguage should be highly inflected — that is, have case endings on nouns and their modifiers and changes in verb endings according to person and tense as in Latin, German and Russian — or "isolating" where person and tense are indicated by the position and order of words in the sentence or by separate words — as in English and Chinese. A highly inflected language would be easier to learn in that it would permit the writer to use his native word order, since as in Latin, almost any word order would be correct and unambiguous. An isolating language, however, would have the advantage of greater simplicity, and, because of its regularity would be easier to comprehend at first reading. Practically, an isolating language must be chosen. Chinese is purely isolating. It would be highly discriminatory against them as well as against ourselves to require them to learn a completely new concept of sentence structure and grammar as well as a new concept in writing. The isolating grammar of the ordered sentence is not foreign to any major language — the subject-verb-predicate form is used in the simplest sentences of almost all. Furthermore, failure to recognize that Asia is an

(*Continued on page 26*)



Back in 1928 Alcoa engineers pointed out the advantages that aluminum would bring to railroad tank cars carrying hard to hold chemicals; easily contaminated foods. So Alcoa designed and undertook to pay for the first aluminum tank car. The car builder and a shipper became interested. On completion of the car, the builder assumed the cost and leased it to the shipper for regular service.

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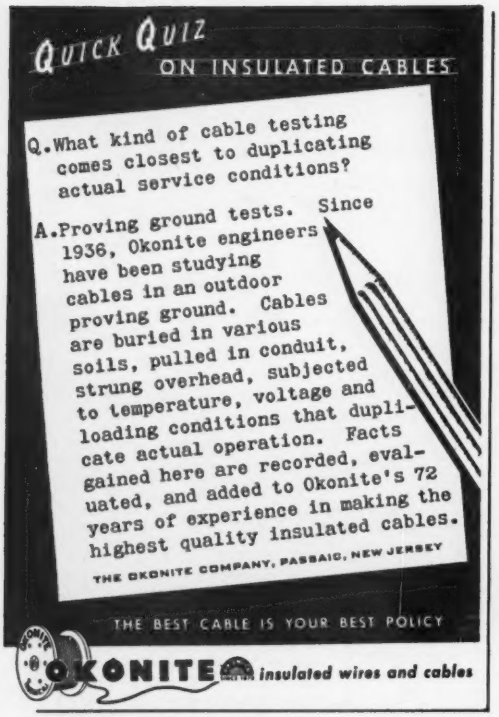
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A. Proving ground tests. Since 1936, Okonite engineers have been studying cables in an outdoor proving ground. Cables are buried in various soils, pulled in conduit, strung overhead, subjected to temperature, voltage and loading conditions that duplicate actual operation. Facts gained here are recorded, evaluated, and added to Okonite's 72 years of experience in making the highest quality insulated cables.
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THE BEST CABLE IS YOUR BEST POLICY
OKONITE insulated wires and cables

a language for science

(*Continued from page 24*)

important part of the world is a near fatal disease, as we have been taught twice in the last decade.

No national language satisfies all or even most of these requirements. Even if one did, nationalistic fanaticism in the other countries of the world would probably preclude its adoption (remember Hitler's attempts to purge the German language of "foreign" words). English, which perhaps comes closest, is highly idiomatic with its universal verb "get" (get — sick, ready, up, started, the paper, etc.) and it is least phonetic of the major European languages. As Thorstein Veblen says in *The Theory of the Leisure Class*, "English orthography satisfies all the requirements of the canons of reputability under the law of conspicuous waste. It is archaic, cumbrous, ineffective; its acquisition consumes much time and effort; failure to acquire it is easy of detection." We must reject Basic English for the same reasons and because of its limited vocabulary.

Since we can't find an acceptable ready-made language, we must tailor one to suit our needs. With the exception of a few code-like systems created by philosophers, proposed artificial interlanguages have used the "international" words and the basic word roots found in many of the European languages to build their vocabularies. Because of the great influence of Latin via the Roman Empire, the Roman Catholic Church, and the widespread cultural and diplomatic use of French, most of these words are of Latin origin, although Hogben's Interglossa, in line with recent practice in scientific nomenclature, uses Greek roots as a basis.

Most of the requirements we have set up have been met by the various artificial languages constructed in the last seventy-five years. However, the fact that most of them are inflected makes them disadvantageous for our purpose. Volapuk, the first to be actually used by a large number of people (several thousand at a minimum) was highly inflected — a verb could take 505,440 different forms. Esperanto (hope), its successor which has had much wider usage and was taught in a few schools (in 1931, 995 schools in 36 countries), is also slightly inflected, the verb having six tense endings and twelve participial endings and an objective case ending for nouns. Interglossa is strictly isolating.

Since soon after its inception in 1887, Esperanto has been the only artificial language to gain widespread usage, has had its own publications, and has been used as the official language for international conferences including some on topics other than interlanguages. It has expanded since then but few changes have been made, although many improvements have been suggested. An organization of linguists and other interested persons, the International Auxiliary Language Association, has been working for years testing and perfecting various modifications of Esperanto, Ido, Panromanal-Universal, Interlingua, etc., and there seems to be general agreement on the principles which should be followed in the construction of an interlanguage.

Thus the problem now is not to find a satisfactory interlanguage — we have several. The problem is to obtain international acceptance and use. Everyone who deals with information or ideas would benefit from the adoption of an interlanguage and, for his own sake, should keep the idea "alive" within his professional organization and support any steps which might be taken toward achievement of this end. This may have to await a settlement of the conflict between Bolshevism and the rest of the world. An interlanguage would, most likely, be an aid in even achieving this, but like a loan, it is most difficult to get when it is most needed.

functions, operators, and fourth dimension

(*Continued from page 15*)

assigns to any function f, another function g. We can think of the functions as themselves forming a collection we can consider to be the domain of a new function.

The notion just presented is a rather abstract one. We are now thinking of functions themselves as the elements of a collection, and we are speaking of functions on this collection which assign, to each function, another function. Sometimes this more general idea of a function is called an *operator*, or a *transform*. It is just a rule which assigns to a function f some function g, and we can say "f is transformed into g" if we like.

One operator with which most readers are familiar is the derivative operator, d/dx, which transforms functions such as x^2 into other functions such as $2x$. We can think of it as a meat grinder, except here it is a function grinder. We put in a function, turn the handle, and out drops another function.

The idea of an operator, or transform, is rather important in mathematics. The reader may have heard of the Laplace Transform, or the Fourier Transform. Each of these is a rule which replaces one function by another. In a certain sense the Laplace Transform is like a logarithm, except that instead of enabling us to multiply by a process of addition, as with loga-

(*Continued on page 30*)

How much do you know about transportation?

Rapid, modern transportation by land, sea and air depends largely on petroleum for power and lubrication. But few realize the wide *variety* of petroleum products required to keep travel and trade in motion. Test your own knowledge.

A few of the many petroleum products needed are listed at right. See how many you can correctly identify with the mode of transportation in which they are used. Check your estimates with the figures in the illustration.

Hand in hand with the advance of modern transportation have been many improvements in the quality of petroleum products. Behind these improvements is a vast amount of progressive, scientific research and the work of thousands of skilled people.

Good jobs with fair pay and a chance to get ahead have helped Esso Standard Oil Company to build a team of 27,000 employees. With its many years of petroleum experience, this team is constantly striving to improve the quality and value of the products at the famous Esso Sign.

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4. Bunker Fuel Oils
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7. Heavy-Duty Motor Oil
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9. Steam Engine Oils
10. Steam Turbine Oils
11. Railroad Car Oils
12. Gear Lubricants
13. Hydraulic Oils
14. Synthetic Rubber

ESSO STANDARD OIL COMPANY

early norse discovery

(*Continued from page 14*)

The fact that they did have a camp one day's journey from the place where the Kensington Stone was found instantly inspired those who felt that the Kensington Stone was authentic to seek the camp site. But the searchers were baffled for many years since there was no lake large enough (it had to be large enough so that the men fishing would be beyond earshot of the cries of their embattled comrades) within a distance of twenty miles, which had been estimated as the distance which the exploring party could cover in a day. Finally Holand conceived the thought that this distance was not necessarily covered in one day by the portaging travelers, but rather was an estimate of the distance that they would have covered if they had been sailing on the ocean. In view of this possibility, the camp site would be on a lake seventy to one hundred miles north of the Kensington Stone. Sure enough, about seventy miles north of the Kensington Stone, Holand found a lake of appreciable size with two skerries on it.

In looking about for some evidences that the Norse explorers had had a camp at that place in 1362, one member of the searching party came upon a boulder near the shore of the lake which had a hole in it. This in itself was no cause for great elation, although a boulder with a manmade hole in it out in a wilderness is somewhat unique. But the fact that the hole showed signs of at least one hundred years weathering did cause considerable curiosity. Upon further searching two other boulders were found within ten feet of the first, also having much weathered holes in them. Two of the holes were but one inch deep but the third hole was seven and one-half inches deep. All were of triangular shape about one and one-quarter inches wide at the widest point. From well authenticated sources, Holand learned that the Norse voyagers of the fourteenth century were in the habit of mooring their ships in the many inlets of the Scandinavian coast, by passing a line from the shore to the stern of their ship and holding the ship out away from the shore by means of an anchor from the bow. The stern line was usually secured at the shore to an iron pin which was driven into an especially drilled hole in a large boulder. The holes in the three rocks at the supposed camp site duplicated the holes drilled in the mooring stones all along the Scandinavian coast in size, location, shape, and angle at which they were drilled. In the course of many years these mooring stones were found in several places throughout the lake regions of Minnesota. As could be expected, a line drawn on a map from the location of one mooring stone to another describes the path of the Norse explorers. The line begins at the mouth of the Nelson River, continues down through Lake Winnipeg, past the site of the Kensington Stone, suddenly turns eastward, and then abruptly stops. In spite of many attempts, no more mooring stones could be found beyond a certain point.

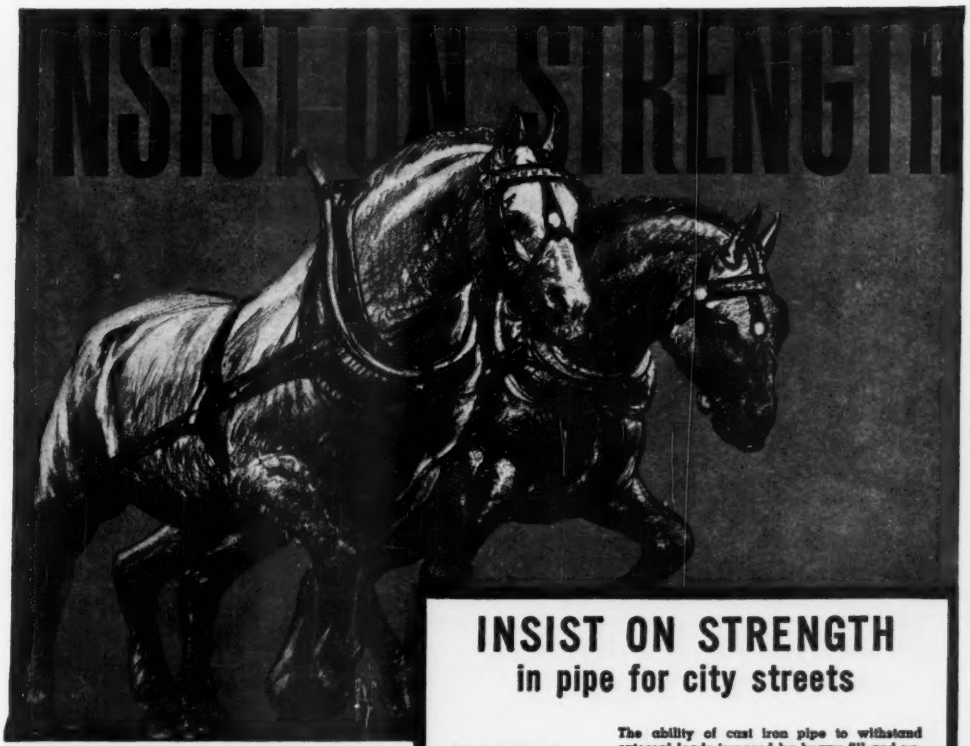
Were these people massacred by Indians at this point? The question of what ultimately happened to this party of explorers makes an intriguing study. Mr. Holand suggests the following explanation as plausible and as having many indications that it was actually what happened to the Norse explorers.

When the first settlers and frontiersmen came to Minnesota they found a tribe of Indians having certain characteristics which set them apart from all other tribes on the American continent. Whereas all other Indians invariably had jet black hair and a dark copper complexion, the Mandan Indians had complexions varying from almost white in some of their women to the usual copper, and these people had all shades of hair, including blonde, with the exception of red. Many of the members of this tribe were blue-eyed. Beyond this, they were the least nomadic tribe on the plains and depended on agriculture as the principal source of their food. The stockades which surrounded their villages resembled European structures, having a ditch on the outside of the pales and with an elevated shooting platform within. One of the tribe's traditions was that their progenitor was a great white man who came from the West in a great canoe. This tradition was so strong that at the time of the coming of white men, a large ceremonial canoe was kept at all times in the center of their villages. These and other indications too numerous to mention here certainly lead us to believe that this remainder of the Paul Knutson party intermarried and became part of the Mandan Indian tribe.

In conclusion then, the evidence that Mr. Holand has gathered opens an entirely new possibility in the history of the American continent. By his investigations into the age of the tree found growing above the Kensington Stone; by observing the effect of weathering on the stone; by the recognition of unfamiliar word forms in the inscription which could not have been known to anyone but a Norseman of this period; by the use of these and other data he has virtually proven that a forgery was impossible and that the Kensington Stone was indeed done by a Norse explorer of 1362. Upon examination of the text of the Kensington Stone, we can see the following places where it corroborates perfectly with the Paul Knutson expedition. Since Paul Knutson's party left Scandinavia in 1355, it would have given ample time for this missionary group to have sailed along the coast of North America from Vinland to the Nelson River on Hudson Bay and by 1362 be near the place where Kensington now stands. The time of return of Paul Knutson's party is further corroboration. The ten men left on the shores of Hudson Bay with the ships probably were given instructions to wait for at least three months. However, Hudson Bay freezes over early in the fall so that the departure of the men at the ships would have been delayed at least until the summer of 1363. In 1363 then, they probably sailed back to Vinland expecting to find the remainder of their group there. When they arrived in Vinland's region and found no one, they were probably much saddened at the loss of their comrades, but returned to Scandinavia, realizing their own inability to alter the situation. The personnel of the Paul Knutson party also agrees with the personnel of the Kensington party. By the decree of King Magnus, the missionary group was to be composed of men of his own retinue and of the retinues of other men. Magnus was a Swede and Paul Knutson was Norwegian; therefore men of both nationalities would be represented in the missionary group. This agrees with the inscription on the Kensington Stone. Further, the fact that the Kensington party was able to write at all indicates that they had members of the clergy along. This also would agree with the Paul Knutson party since because of their religious mission, we can expect that they had one or more priests in their party.

Another point, not mentioned previously, which serves to verify the theory that there were Norsemen in Minnesota in 1362 is that some twelve war axes have been found throughout the area through which the Norse explorers are supposed to have traveled.

(*Continued on page 30*)



Long life and low maintenance cost of mains laid under city streets depend not only on effective resistance to corrosion but on definite strength factors. The four strength factors that pipe must have to withstand beam stress, external loads, traffic shocks and severe working pressures, are listed on the page opposite. No pipe that is deficient in any of these strength factors should ever be laid in paved streets of cities, towns or villages. Cast iron water and gas mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe not only resists corrosion but combines all the strength factors of long life with ample margins of safety.

INSIST ON STRENGTH
in pipe for city streets

CRUSHING STRENGTH

The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

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When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

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The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 8 times *on the same spot* from progressively increased heights of 8 inches.

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In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

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early norse discovery

(*Continued from page 28*)

Quite significant is the fact that exact duplicates of these axes are to be found in museums of the Scandinavian countries. The museum pieces are listed as axes used in the fourteenth century by the Norsemen. The French and English explorers who first came West after the discovery of our country by Columbus used no weapons which resembled these relics found in Minnesota.

There have been a few articles written in refutation of Holand's claims; however, the questions raised by these articles have concerned only petty points in all instances. In any event, Holand has assembled a great preponderance of evidence in verification of the inscription on the Kensington Stone. Unique as Holand's theory is we must accept it as true. Unless some evidence appears which disproves Mr. Holand's assumptions, our long-standing homage to Columbus as the discoverer of America has been poorly placed and to the intrepid Norsemen should go the credit for discovering and exploring America first.

functions, operators, and fourth dimension

(*Continued from page 26*)

rithms, we can take a derivative by a process of multiplication. So we can solve a linear differential equation by transforming it; the problem becomes simply a matter of solving an ordinary algebraic equation. The Fourier Transform, on the other hand, may be likened to a mathematical prism, which gives us the spectrum of a function, just as an optical prism gives us the colors of the rainbow. We can study the light frequencies that make up a beam of light by passing the beam through a prism, which disperses the light into its component colors. Similarly we can think of certain functions as being made up of a mixture of sine waves of various amplitudes. The transform of a function $f(x)$, becomes $g(\omega)$, where ω, Greek omega, stands for frequency, and $g(\omega)$ gives the amplitude at this frequency.

Four-Dimensional Space

Let us return to our previous example. Since it is difficult to think of "the set of all functions on the letters a,b,c,d," it is convenient to make a geometrical model of this "collection of functions," that is at once esthetically more satisfying, and practically most useful. The way we do this is as follows: First we observe that we completely specify a function when we give the four values that it can assume, $f(a)$, $f(b)$, $f(c)$, $f(d)$, in that order. This is the reason that we chose the four letters a,b,c,d as the domain of our function, rather than speaking of complicated functions such as those of M11, where the entire X-axis is the domain. Our functions are easier to define than the functions of M11, since there are an infinite number of points on the X-axis, so we could hardly list all the values of the function.

So now we specify a function by giving, in order, the four values it assumes. For example, the function $g(x)$ which we have discussed can be written (3,5,7,9).

Now we recall that, in freshman calculus, a point in the X-Y plane was designated by giving its two coordinates (x,y). In sophomore calculus, the mathematical treatment is extended to three variables, and we discuss points and vectors in three-dimensional space. A vector from the origin to a point can be designated by giving the three coordinates of the point, (x,y,z). What could be more natural, then, than to consider the functions, which we can write in a similar way, as vectors in a four-dimensional space, vectors having four components? For example, $g(x)$ is now considered to be the vector (3,5,7,9) in a four-dimensional space, having component 3 along the X-axis, 5 along the Y-axis, 7 along the Z-axis, and 9 along the fourth axis. This fourth axis is, of course, perpendicular to each of the other three!

Some people seem a bit annoyed at this, but there is really no reason for annoyance. Most of the ideas of M21 extend with no difficulty to four dimensions. We can talk about scalar products and lengths and the usual things, so why not? Of course, that extra fourth dimension cannot be visualized so easily, but this is no handicap at all. There are many students who have difficulty visualizing three dimensions, but they somehow manage to pass M21.

From a mathematical point of view, four dimensions is quite modest; infinite dimensional spaces have become commonplace by now. Even for the practical person four dimensions is not usually enough; the physicist

(*Continued on page 32*)

Build Confidence ON BROAD EXPERIENCE

by ARCH COOPER
Manager, Empire Region
ALLIS-CHALMERS MANUFACTURING COMPANY
(Graduate Training Course—1909)

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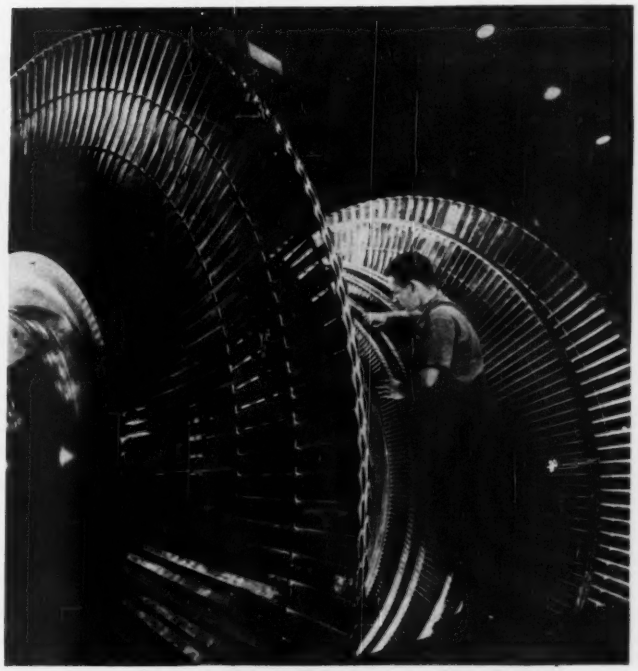
It's a good credo for salesmen, but it takes broad experience to carry it out. It's the kind of experience you must deliberately set about acquiring as early as possible. I had heard of Allis-Chalmers equipment, seen A-C's giant Corliss engines in Australia's biggest power plant and decided to study design at Allis-Chalmers. It looked like the best place in the world to get a broad engineering background.



High temperatures and speeds raise tough design and production problems on giant steam turbine spindles like these.

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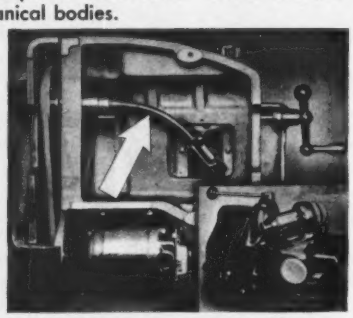

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functions, operators, and fourth dimension

(*Continued from page 30*)

is better acquainted with phase space, which has six.

The study of mathematical systems, such as numbers, matrices, tensors, or n-dimensional vector spaces, is a small part of a vast field that mathematicians call *algebra*. The heart of modern algebra is the process of abstraction, in which we strip away all but a few basic parts of a mathematical system, and see what can be deduced from what remains. The subject known as *group theory*, which the engineer encounters in his study of similitude, or in crystallography, and which the physicist encounters in quantum mechanics, is a part of algebra in this modern sense.

Topology

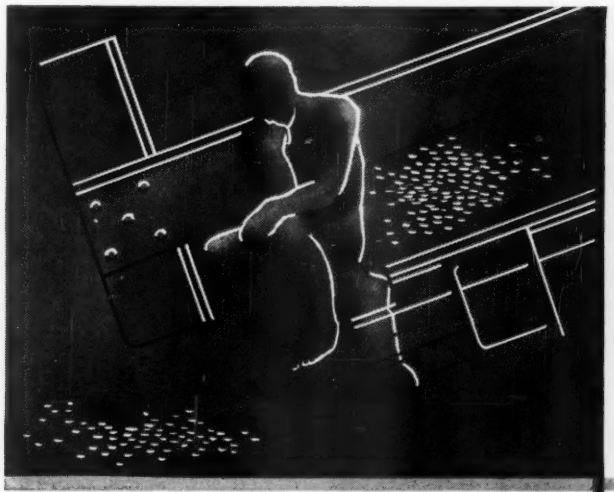
The advantage of speaking of "spaces of functions" is that certain geometrical ideas can now be applied to the study of functions. Of course, the functions that are of importance in mathematics, are functions that have an infinite domain, for example, $f(x)$, where x can be any real number. Such a function calls for an infinite dimensional space, and it is not true that the simple ideas of M21 extend to such spaces. We find that the spaces of functions that occur in mathematics may be very much different in their properties from the geometrical objects that we are already familiar with. The study of the geometrical properties of abstract spaces belongs to a branch of mathematics called *topology*.

Most popular books that discuss topology emphasize the nonorientable Möbius Strip, the Klein Bottle, and the like, and in so doing make people think that topologists must spend their time cutting out strips of paper or modelling in clay. It is well to keep in mind that topology began as a branch of analysis, and has a close connection with analysis. Many of the theorems of advanced calculus, which appear so complicated to the beginner, have simple geometrical explanations when we think of certain classes of functions as forming a "space."

In Conclusion

When we pass from the interesting structure of ideas, of which this article only hints, to the routine drill problems that dominate most classroom discussions, we pass from mathematics into a no-man's land that neither the mathematician nor the engineer claims as his own, but in which the mathematician has been appointed the guide because his predecessors, alas, were the trail-blazers. Some people enjoy long calculations with complicated analytical expressions, for their own sake. Apparently there are even people who think that every freshman should learn the manifold tricks of integration. We must be patient with these people, just as the radio engineer must be patient with the technician who is proud of the vacuum tube characteristics he has memorized. One does not design a new circuit by sitting, with feet on desk, thumbing through an electronics magazine, but a certain amount of education is needed to realize that.

Calculations are far from the heart of mathematics, and once systematized, they have no place in the heart of mathematicians. The student who thinks of mathematics in terms of problem-solving techniques is like the student who thinks of history as a collection of dates and names; he misses the point completely. It is to that rare student who sees some meaning in the little mathematics he has studied, and who desires to seek a further understanding, that this invitation is extended.



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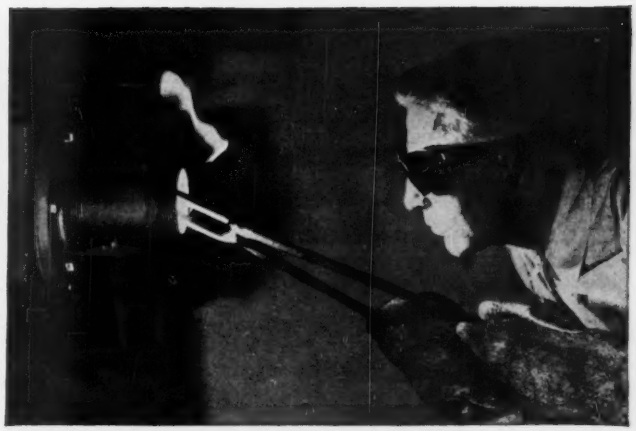
In the Norton Mechanical Laboratory W. M. Wheildon, Jr., B. S. and M. S., Massachusetts Institute of Technology '30 and '31, takes readings on a wear-testing machine which he developed.



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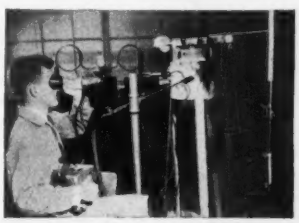

In the Norton Ceramic Laboratory O. J. Whittemore, Jr., B. S., Iowa State '40, operates a load test furnace of his design — a furnace that tests refractories at temperatures up to 2450°C.

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Making better products to make other products better

ABRASIVES · GRINDING WHEELS · OILSTONES · ABRASIVE PAPER & CLOTH

GRINDING & LAPPING MACHINES · LABELING MACHINES · NON-SLIP FLOORING

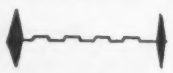
REFRACTORIES · CERAMIC SURFACE PLATES · BORON CARBIDE PRODUCTS

NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

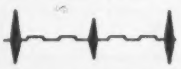
BEHR-MANNING, TROY, N. Y. IS A DIVISION OF NORTON COMPANY

HOW IT WORKS

Supersonic waves are sent into the material under test. Upon reaching the other side, or upon reflection by a discontinuity, the waves return to their source and are then converted into a high-frequency potential. This potential is amplified by electronic circuits and projected upon the screen of a cathode-ray tube where they may be seen and examined.



Pulse pattern, showing the initial pattern at the extreme left and the reflection from the opposite side at the extreme right. The sweep line indicates no defects.



A typical indication of a defect is illustrated here. By means of calibration, it is now possible to determine both the exact position of the flaw, as well as its size.

Non-destructive Supersonic testing is another in a constant succession of new techniques employed by Grinnell to provide prefabricated piping that is safe and dependable.

Grinnell's ultra modern electronic testing can be relied upon to detect hidden flaws in pipe materials, to check unerringly the quality of welds where it picks up flaws not revealed by X-ray and gamma ray inspection. In examining bends, this method of testing can measure the degree to which bent pipe thins on the outside and thickens on the inside of the bend, assuring full specified thickness in high temperature, high pressure work.

Utilization of modern equipment of this type is one of many sound reasons why it pays to call in Grinnell "Whenever Piping Is Involved". Grinnell Company, Inc., Providence, R. I. Branch warehouses in principal cities.

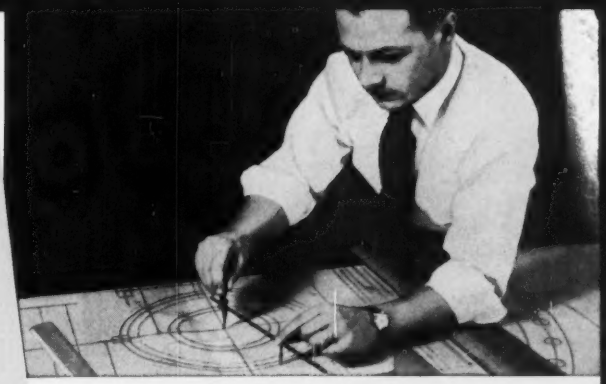
GRINNELL

WHENEVER PIPING IS INVOLVED

pipe • valves • Grinnell-Saunders diaphragm valves • pipe and tube fittings • welding fittings • engineered pipe hangers and supports prefabricated piping • Thermolier unit heaters • plumbing and heating specialties • industrial supplies • water works supplies Grinnell automatic sprinkler fire protection systems • Amco humidification and cooling systems.

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

Extreme accuracy makes photography a matchless engineering tool

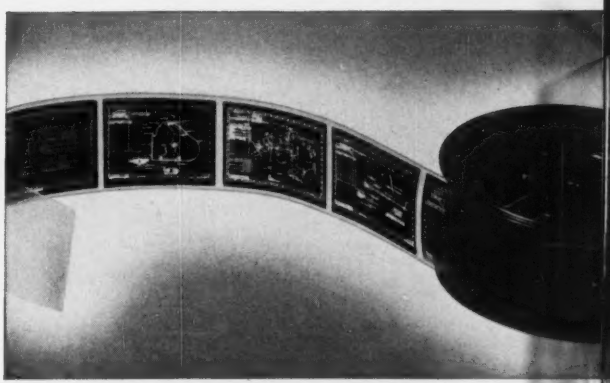


DRAWINGS ARE COPIED FAITHFULLY. Photocopying reproduces engineering drawings, data, specifications, with high speed, utmost accuracy and in any quantity. Bright copies can be made from dimmed material. Originals are saved from wear and tear.

Accuracy is but one of the unusual abilities of photography which are important in engineering and other professions and businesses alike. Through its speed it can provide movies that slow down action which would be far too fast for eyes to follow. Through radiography it checks castings, welds, and assemblies without destroying the part.

And so it goes all through the profession. You find photography saving time, improving products and procedures, simplifying processes.

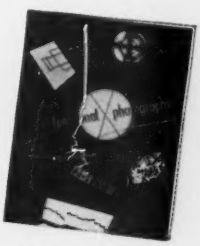
Eastman Kodak Company, Rochester 4, N. Y.



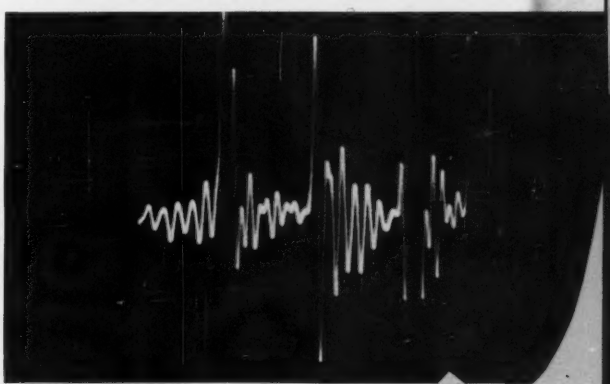
IMPORTANT RECORDS PRESERVED. With microfilming, engineering drawings and valuable records can be preserved with every detail intact. The film can be stored for easy reference in 98% less filing space than the originals would require.

College graduates in the physical sciences, engineering, and business administration regularly find employment with Kodak. Interested students should consult their placement office or write direct to Business and Technical Personnel Department, Eastman Kodak Company, 343 State Street, Rochester 4, N. Y.

Send for this FREE Book

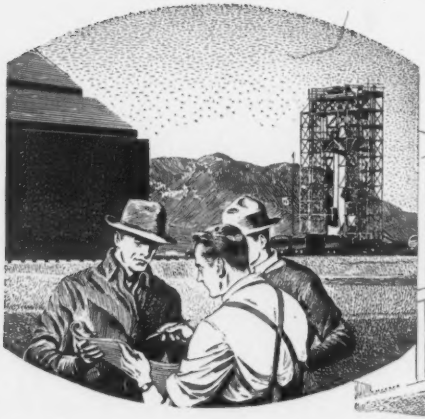


It tells how photography is used to:
Speed production · Cut engineering time
Assure quality maintenance · Train more workers faster · Bring new horizons to research



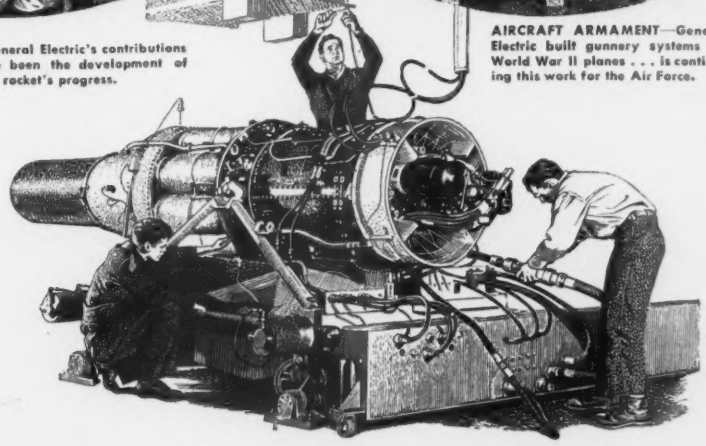
INSTRUMENT READINGS RECORDED. Fleeting traces of the galvanometer mirror or cathode-tube beam can be recorded for study and analysis. Movement too fast for the eye is caught accurately by photography.

Kodak
TRADE-MARK



GUIDED MISSILES—Among General Electric's contributions to this military project have been the development of compact transmitters to report rocket's progress.

AIRCRAFT ARMAMENT—General Electric built gunnery systems for World War II planes . . . is continuing this work for the Air Force.



JET ENGINES—In 1941, the Air Force asked General Electric to build the first U.S. jet engine. Today, G-E engines power such fast planes as the F-86 Sabre, holder of world's speed record.

College graduates at General Electric are working on some of the nation's most vital projects

The rocket that rises a hundred miles above White Sands, N. M., contains a wonderfully compact device that reads 28 instruments every one-thirty-fifth of a second and transmits its reports to receivers on the ground. It was developed by G-E engineers . . .

Development of special communications systems for civil defense has been undertaken by G-E electronics engineers . . .

The newest class of Navy heavy cruisers helping to guard our defense line gain their power from 30,000-horsepower propulsion turbines built by General Electric . . .

It is estimated that during 1951 more than 30 per cent of General Electric's production will comprise projects like these . . . the design and construction of equipment to help fill America's military needs.

The hundreds of General Electric engineers, physicists, chemists, and other specialists sharing in these projects work with the assurance that their contributions are meaningful and important. Their talents and skills, further developed through G-E training courses and broadened through rotational job programs, are standing the nation in good stead.

You can put your confidence in—

GENERAL ELECTRIC